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Money values will be expressed in U.S. dollars unless otherwise specified. The spelling "tonne" will be used to indicate metric tonnes (1000 kilograms), and "ton" will refer to traditional U.K.-U.S. tons (2000 lbs. or 2400 lbs.).

AGRICULTURAL PRICING

Agricultural Pricing Policies

Gordon Donald

[This article attempts to do three things: (1) an introductory orientation to the subject matter, intended for non-economist readers; (2) a summary description of policy positions taken in A.I.D. and the World Bank; (3) a brief look at some of the research in agricultural pricing.]

All governments take a variety of actions that affect the prices of their agricultural products. Some governments try to regulate prices, keeping them either high or low; others avoid direct regulation but engage in a number of activities that indirectly do something to farm product prices. Taxes on exports, imports or domestic sales of a product, or subsidies affecting its production costs will change its price. A high-level exchange rate for a country's currency will depress the local prices of farm goods that are export products, and encourage imports. Building a road and storage facilities into, say, a wheat growing area will make wheat prices more favorable to farmers and/or lower to city consumers. Research and extension activities supported by governments can do a great deal to lower costs and increase supplies of the agricultural products affected by scientific discoveries or improved varieties developed for local conditions. Agricultural credit institutions can also help or hinder changes.

These various actions can be taken with a conscious pricing policy in mind, but often they are not. Rather, a government finds itself imposing import and export taxes to produce revenue and maintaining an overvalued exchange rate mainly for financial reasons, while its road building and research budgets tend to emerge from a pulling and pushing of people with many different interests. Still, the level of farm prices, and especially the prices of common foods, are very important matters. They can arouse strong feelings in consumers and in farmers, and can sometimes shape political events. In this and the articles

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Development Digest.

that follow we will consider some of the major issues involved in agricultural pricing.

Priority Given to Agriculture

One contrast in policy making stands out: one group of countries, predominantly the high-income industrial countries--the U.S., Western Europe and Japan--keep many of their agricultural prices high, while the lower-income countries generally tend to hold prices down, below international levels. In the more industrialized nations the numbers of farmers in the total population have diminished to very low levels; yet their political influence appears strong--reinforced in part by a desire for national food security, despite higher food prices in the cities. In low-income countries the opposite is found: farmers, and rural populations dependent on local agricultural prosperity, are a much bigger percentage of the population, but their interests tend to be neglected while those of urban consumers are far more influential on policy.

There are reasons for this difference, discussed more fully in other papers below. These include the desire of low-income countries to emphasize industrial growth and to look on agriculture as relatively "backward," and indeed such a view was implied in much of the advice given by development experts in the 1950s and 1960s. Today, agriculture is given a much higher priority in development strategies recommended by a great many of the specialists in leading institutions, partly as a result of intervening experience. One result of these policy differences is that the net exports of grains from North America and Australia, and more recently Japan and Western Europe, have been growing and in effect helping to feed the world, while the net imports of the other countries have been increasing. In this respect the USSR, China and Eastern Europe belong with the developing countries.

Economic Efficiency

While the relative priority given to agriculture is obviously important in pricing policy, there is another dimension that needs emphasis: economic efficiency. This is a subject much discussed by economists, and when they are writing for their colleagues in the profession their terminology sometimes leaves non-economists in the dark. This is unfortunate, since the subject matter is important and the basic ideas are not difficult to grasp. Their application can be very complex when national policies are being considered, and major decisions should not be based on simplified analysis. Nevertheless, a few words of orientation to this contentious area may be helpful since the following articles are written by economists and employ standard terms and assumptions.

Efficiency generally means the production of a desired result with the minimum expenditure of energy, time, materials, or money. The same idea could be expressed as obtaining the maximum of desired results from given inputs of energy, time, etc. In order to put this idea into a form that can be used for measurement, and thus for judgments on what is more efficient than something else, it is necessary to define the inputs and outputs in uniform terms. Energy efficiency, for example, compares inputs of units of energy with outputs of the same. Economic efficiency covers use of all types of resources, and this requires measuring the inputs of time, energy and materials in money values. Such measurements indicate that efficiency is identified with lowest cost of production of something desired. It is more problematical, however, to measure the amount of desired results in money terms; different people have different desires and priorities. The most objective way of doing this for a large number of people, such as a nation, would be to let them spend their money freely on various products offered in a market. Buyers would pay more for what they valued higher; producers would have to cover their costs to make a sale. The results would be prices that would reflect both the buyers' relative desires and the relative costs of resources used by producers to satisfy these desires.

The interaction of consumers and producers through sales at agreed prices is one that needs to be flexible if it is to accomodate a variety of changes. These include shifts in demand by consumers, but also new conditions affecting costs such as technological change, new transportation facilities, new products, etc. Producers are seen as competing with one another to attract buyers, and consumers are competing for lower prices or better products. In this scenario, free movement of goods, people, and prices is seen as the best guarantee of efficiency for the system as a whole.

This identification of free movement with system efficiency is a shorthand statement of what many economists would consider a practical rule of thumb for policy guidance. Not all economists would agree; and no economists would follow this line of thought without at least some qualifications. In other words, a great many economists would approve of free markets as a general rule to aid efficiency, but most would add that there are some carefully defined circumstances in which specific forms of government intervention into markets would (or could) be justifiable with no loss of efficiency.

This is not the occasion to discuss fine points of economic theory, nor to explore in detail the many value judgments that could be applied to the results of economic analysis for translation into policy. Combating malnutrition, and helping particular social or income groups, would be examples of influential social values. Policy makers do, of course, have other objectives than economic efficiency, and

often the non-economic aims will be clearer in their minds. What economists can say to them on many occasions is something like this: you may intend to accomplish--as a common example--the improvement of some favored group, like the poor people in a city who need more food, by imposing a price ceiling on the price of staple food in the market. But you will also set in motion a number of other changes that you have probably not considered, and may not intend, and the effects of these changes may be fully as important as the change you wish to make; in fact, the unintended changes can sometimes cancel out or reverse the intended change in the longer run.

To follow up with this example: a price ceiling on food sold in cities adds to the welfare of all city people, rich or poor, unless access to the food is somehow limited to the poor; this is hard to arrange, and harder still to enforce if the foodstuff that is controlled becomes scarce. A ceiling price means that somebody gets paid less for their product than they otherwise would, and this decrease is generally passed back to the farmer. This starts up a chain of reactions if it occurs on a large enough scale to be significant. Farming becomes less profitable, at least in the production of price-controlled comodities: less labor time will go into this activity, less capital will be invested in land improvement, less income will be generated in rural areas, less will be paid in rural taxes, loans may be defaulted, etc. etc. A number of rural people will be negatively affected, directly and indirectly, and future food supplies for the nation will be reduced. And when one considers that rural incomes are generally much lower than urban ones and that the majority of the poor in most developing countries are found in rural areas, one can question whether an urban price ceiling intended to help the poor will not end by helping more of the wealthy and damaging more of the poor.

There is a way around this problem, but it has its cost also. A government agency can buy food at higher prices from producers and sell at cheaper prices to consumers by subsidizing the agency's losses from general state revenues. The subsidy is then paid by taxpayers; and the money that is devoted to subsidizing food consumption in the cities is taken away from other things the government could do --such as building roads, or supporting research, or initiating other developmental projects. This kind of subsidy can creep up in size and over time, and most governments simply cannot afford to carry this approach too far.

Development Agency Views on Agricultural Pricing

Recent policy statements from the U.S. Agency for International Development (AID) and the World Bank indicate a trend in thinking that is increasingly skeptical of government interventions in agricultural markets. And the World Food Council, a United Nations body,

concluded its June 1983 meeting with a plea to African countries to increase their price incentives to farmers in order to reduce famines and restore the continent's self-sufficiency in food.

"Pricing, Subsidies, and Related Policies in Food and Agriculture" (A.I.D. Policy Paper, November 1982) is quite explicit in its conclusions and their policy implications. It analyzes governmental price and distribution controls and related taxes or subsidies in food and agriculture. It focuses most heavily on price ceilings and distribution controls on urban food sales; price controls on agricultural inputs, such as fertilizer; and controlled interest rates on agricultural loans--i.e., the price of credit. The analysis finds that for the most part government interventions in agricultural markets tend to reduce efficiency in resource allocation and inhibit gains in productivity, and often do little for groups they are supposed to help who could be better helped in other ways. The Policy Paper, however, cites three examples of areas in which government intervention can be valuable: (1) agricultural research and new product development; (2) special feeding programs to combat malnutrition; (3) building large scale irrigation systems.

AID's choice of projects to support, and the direction of its efforts at persuasion, will favor food distribution programs that are: targeted to particular groups with unmet nutritional needs; that do not rely on suppressing prices to producers; that obtain supplies at low cost; and that do not attempt to regulate food for the bulk of consumers but leave that to the market. Subsidies to agricultural inputs (fertilizer, pesticides, etc.) are justifiable only temporarily within projects to introduce new techniques to farmers, and should be phased out by the end of a project. Agricultural lending institutions receiving AID support should set interest rates according to the market demand for funds, or should make substantial efforts to reduce controls where they exist.

The World Bank's paper on this kind of subject, "Agricultural Prices, Subsidies and Taxes: a Summary of Issues" (Policy Note No. 3, February 1979) is presented in a less explicit tone than AID's, but the underlying analysis seems consistent in the two approaches--even though neither institution has any responsibility for policy positions of the other. The flavor of the Bank's paper may be conveyed by quotations from the initial Summary and Conclusions (pp. i-ii).

"Agricultural intervention policies in developing countries have developed haphazardly as a result of various historical pressures.... The net effect of such policies in many developing countries is to create disincentives to agricultural production.... Overall economic growth has probably not been assisted by low price policies toward agriculture since they have impeded the direct contribution of agri-

culture to economic growth and to the balance of payments, and encouraged rural-urban migration... [such policies] have tended to lead to inefficient resource allocation between industry and agriculture and within agriculture, reducing agricultural output and employment.... Given the relatively high price elasticities of supply found in developing countries, higher incentives can be considered an important instrument for increasing food production.... Subsidies on inputs have proved an inefficient way of protecting agriculture, leading to overuse of subsidized inputs." Other statements note the complexity of the effects of agricultural prices on different groups, and advocate a gradual rise in food prices to avoid the hardships resulting from an abrupt increase.

Research in Agricultural Pricing Policies

Readers of the Development Digest will find a section on agricultural pricing policy in the July 1981 issue (pp. 23-54), with a general article by Gilbert T. Brown and reviews of experience in Egypt by William Cuddihy and in Sri Lanka by J. Gavan and I. S. Chandrasekara.

In the late 1970s the World Bank undertook a series of studies of the agricultural pricing situations and policies of some leading countries that were published in 1980 as World Bank Staff Working Papers (listed below). This was a serious effort to explore the complexities of a subject in which it is very difficult to disentangle and attribute causes and effects when one gets into the details of national experiences. We cannot do more here than give a few highlights of the findings; interested readers (who are versed in economic terminology) should consult the studies mentioned.

The paper on Egypt (No. 388) describes a dominant policy theme since 1952: it is an industrialization strategy that involved taxing the agricultural surplus to get investment funds, and keeping industrial costs down by low wages and cheap food. Other policies were intended to help small farmers (land reform, state ownership and subsidies, various physical controls) but kept changing, resulting in an uncoordinated patchwork of contradictory influences. The overall policy results included: the surpluses in Egypt's major crops--wheat, cotton, rice, also sugar and maize--were indeed taxed, but the gains went far more into subsidies to consumers than into investment. Production of most crops lagged behind growth rates in other developing countries; there was evidence of strong responsiveness among crops to price and other (negative) controls; productivity, high in some crops initially, declined; net exports have decreased or become net imports. A few products, however, have flourished--meat, fruits and vegetables; these are not generally purchased by poor consumers.

In Pakistan (No. 387), much of the pricing effects of policy resulted from the foreign exchange controls and trade controls, more than from price fixing *per se*. Subsidies on wheat sold at low prices in ration shops, and subsidies on fertilizer and pesticides were important in the budget, offset by export and domestic excise tax revenues. While there were changes over time and differences among products, the tendency was to keep domestic farm prices lower and more stable than world prices. Nevertheless, it does not appear that depressing effects were sufficient to prevent an overall rate of agricultural growth well ahead of population growth, and reasonable development of productivity with improved inputs.

The Argentine study (No. 386) describes policy shifts in the 1950-75 period which were predominantly adverse to agriculture. The country is found to have a comparative advantage in growing wheat, corn and grain sorghum, all of which have been subjected to significant export taxes (more in the 1950s and early 1970s than in the mid 1960s). Consumers have been the main beneficiaries of overall policies, both as wheat (bread) consumers and as meat eaters benefitting from cheap feedgrains. The author estimates values for the annual losses to grain producers from the complex of policies, equal to the sum of tax collections and consumer benefits plus net social costs. These losses were a very large fraction of the value of production; they amounted to a discounted present value of about one billion (1970) dollars over 25 years.

Other papers in this series dealt with Thailand and India. A final paper (No. 394) reviews the development of methodologies for measuring price intervention effects. Only one item from this study will be noted: a table in the paper supplies a rough grouping of the values found in a large number of studies on the price elasticities of supply in developing countries, that is, the ratio of a percentage change in production to the percentage change in price--negative or positive--which (presumably) caused it to occur. These include long- and short-run elasticities. The reason this table is of interest is that the proponents of price ceilings allege that farmers are set in their ways and do not react very much to price differences, so that little harm is done by depressing farm prices. Here is an accumulation of evidence on that point in 146 cases, and it strongly suggests that prices do matter, that farmers do indeed respond to them in their productive behavior. An unweighted tabulation of pertinent studies indicates the following array of elasticities:

Elasticity of 0 or Less:	16 cases
Elasticity of 0 to 1/3:	46 cases
Elasticity of 1/3 to 2/3:	32 cases
Elasticity of 2/3 to 1.0:	20 cases
Elasticity of over 1.0:	20 cases

(Source: World Bank Staff Working Paper 394, p. 30.)

Aside from the World Bank series, much important research on agricultural policies in developing countries is published by the International Food Policy Research Institute (IFPRI), Washington, D.C. While IFRPI has not focused on pricing policy as did the World Bank, its work is of value in covering the experiences and considerations pertinent to pricing decisions.

This very summary introduction to pricing problems will be taken further in the articles that follow. Professor Schultz emphasizes the importance of economic incentives for farmers in furthering a nation's development. Scandizzo and Tsakok describe some of the problems encountered in food rationing programs and the ways in which they may be judged. Timmer and Falcon have developed a model indicating the key importance of rice and fertilizer prices in determining production and yields in Asia's basic food staple. In one way or another, all agree that prices do matter.

List of World Bank Staff Working Papers Dealing with Agricultural Pricing (April-June 1980):

No. 381 Some Aspects of Wheat and Rice Price Policy in India, Raj Krishna and G. S. Raychauduri.

No. 385 Thailand: Case Study of Agricultural Input and Output Pricing, Trent Bertrand.

No. 386 Argentina: Country Case Study of Agricultural Prices and Subsidies, Lucio G. Reca.

No. 387 Prices, Taxes and Subsidies in Pakistan Agriculture, 1960-76, Carl Gotsch, Gilbert Brown.

No. 388 Agricultural Price Management in Egypt, William Cuddihy.

No. 394 Methodologies for Measuring Agricultural Price Intervention Effects, Pasquale L. Scandizzo and Colin Bruce.

On the Economics and Politics of Agricultural Incentives

Theodore W. Schultz

[Governments in many low-income countries tend to undervalue agriculture, and low prices discourage farmers from producing. The lack of incentives to expand extends beyond farmers to those who supply agricultural capital and agricultural research. The potential of agriculture in these countries is unrealized.]

It is obvious that in many parts of the world there is not enough food. Clearly more food coupled with better nutrition is needed. It is also evident that in most low-income countries such additional food and improvements in nutrition depend largely on increases in and improved composition of agricultural production. But there are pervasive physical and biological constraints on agricultural production along with various unsolved environmental problems. As every farmer and agricultural scientist knows, Nature tends to resist the food-producing endeavors of man. Although there is still much land that could be made suitable for farming, it is for the most part harsh land. The properties of its soil, climate, and biological environment are such that it requires substantial investment to make such land suitable for farming. With the exception of large irrigation and drainage facilities which have to be built by governments, most of the land-improving investments that are required to increase the productivity of both unused land and worn-out soils must be made by farmers.

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Farm Entrepreneurs

Farmers the world over, in dealing with costs, returns, and risks are calculating economic agents. Within their small, individual, allocative domain they are fine-tuning entrepreneurs, tuning so subtly that many experts fail to see how efficient they are. Farmers, although they differ for reasons of schooling, health, and experience in their ability to perceive, interpret, and respond to new events in their farm enterprises, provide an essential human resource which is entrepreneurship. On most farms there is a second enterprise, the household one, and from the viewpoint of economic activities, housewives are also entrepreneurs in allocating their own time and in using farm products and purchased goods in household production. This talent of entrepreneurship is supplied by millions of men and women on small-scale producing units; and on this score, agriculture is a highly decentralized sector of the economy. Where governments have taken over the entrepreneurial function in farming, they have been far from efficient in modernizing agriculture. Where governments have not nationalized agriculture, the entrepreneurial roles of farmers and of farm housewives are important, and the economic opportunities open to them really matter.

Governments of many countries seriously constrain the entrepreneurship of farmers and of farm housewives and thereby reduce the efficiency of agriculture and the standard of living of farm families.

Inevitability of Disequilibria

It is possible to specify conditions under which agriculture would have arrived at a long-run equilibrium. Under such conditions the economic activities of farm people would be that of traditional agriculture. Farming would be essentially routine. There would be no new technology, no alterations in land being farmed, in the equipment used, or in the labor employed. The productivity of each of the various agricultural resources would remain constant, and the demand could be such that there would be no changes in relative prices. Under these conditions, long-run costs, risks, and returns would be known almost with certainty. Accordingly, there would be virtually no entrepreneurial function; routine management would suffice.

But the agriculture in most countries today is not in such a persistent equilibrium state. On the contrary, the transformation of traditional agriculture into an increasingly more productive state, a process that is commonly referred to as "modernization," entails all manner of adjustments in farming as new and better opportunities become available. The value of the ability to deal with disequilibria is high in a dynamic economy.

Two important inferences can be derived from the economic dynamics of agricultural modernization. First, economic disequilibria are inevitable. They cannot be eliminated by law, by public policy, and surely not by rhetoric. Second, the function of farm entrepreneurs in perceiving, interpreting, and responding to new and better opportunities cannot be performed efficiently by governments.

Incentives

Despite some arguments in New Delhi early in 1966 calling for government prohibition of imports of high-yielding seeds, the minister of agriculture decided to import the new Mexican dwarf wheat seed. Some 18,000 tons of this wheat arrived from Mexico in late spring of 1966. The new seed was well suited to the agriculture of the Punjab and to adjacent areas. The farm price of wheat in India was high. The increase in the yield of the new seed enhanced the profitability of producing wheat. The farm entrepreneurs of the Punjab quickly adopted the new seed because the incentives to do so were highly favorable. The wheat agriculture of parts of north India became impressively dynamic. Production increased rapidly. Landowners profited and real wages of farm labor rose. We called it a Green Revolution. Then, all too many analysts in India and abroad turned to making predictions about the unfavorable social side effects of this type of economic dynamics, instead of searching for ways of duplicating the Punjab success in other parts of agriculture.

What is needed are many Green Revolutions that would increase agricultural production throughout low-income countries. They could be had, but they are presently suppressed by the lack of adequate incentives. The state of incentives is such that in many countries it is unprofitable for farmers to undertake modernizing investments that would increase the productivity of agriculture.

What are the incentives to which farmers respond? Response is based on economic information that farmers use in calculating their expected costs, including risks, against the returns they expect to receive. The result of this calculation is an incentive to achieve economic gains and avoid losses. The cost expectations encompass the rate of interest, rent on land, payments for irrigation water, equipment, fertilizer, other current production expenditures, and wages paid for labor, including the value of the farmer's own time devoted to farming. On returns, the expectations encompass the value placed on the farm products to be utilized in the farm household and the expected price of that part of production to be sold.

Governments, however, by various means often alter competitive market incentives. The agricultural production effects of what governments do is a measure of the value that governments place on

that production. There are countries (1) in which agricultural production is neither overvalued nor undervalued, (2) in which it is overvalued, and (3) in which it is undervalued.

There are very few countries that fully satisfy the specifications of the first classification. The countries in which the economic activities of agriculture are overvalued are predominately high-income countries. Members of the European Economic Community qualify. High taxes are levied on cereal imports; these were increased again in 1977 to offset the decline in world market prices. Since World War II, the large increases in grain production in France have been in large part a response to the very high internal European Economic Community prices. Beef imports are restricted to the point that they are virtually nil. Milk is greatly overpriced; there is underconsumption, overproduction, dumping of butter abroad at large public expense. The production of costly sugar beets in temperate Western countries is a long-standing classic example of the overvaluation of a major agricultural product within a large set of countries. In the Orient, the vastly overpriced rice in Japan is still another case in point. The third classification consists predominantly of low-income countries. Major agricultural products are undervalued, and the adverse production consequences of this undervaluation are serious. Whereas high-income countries presumably can "afford" to indulge in overvaluing agricultural products, the food situation in many low-income countries is such that they can ill afford to forego the increase in agricultural products which is lost as a consequence of economic policies.

Where production is overvalued, the producer incentives are too high to be optimal; where it is undervalued, producer incentives are below optimum. The observable effects on production strongly support these implications. I shall concentrate on the adverse production effects of policies in low-income countries that undervalue agricultural production.

It is my contention that the unrealized economic potential of agriculture in many low-income countries is large. The technical possibilities have become increasingly more favorable, but the economic opportunities that are required for farmers in these countries to realize this potential are far from favorable. Thus, for want of profitable incentives, farmers are not making the necessary investments, including the purchase of superior inputs. I believe that interventions by governments are the primary cause of the lack of optimum economic incentives. Although it has not always been by design, the state of incentives in many low-income countries suppresses the economic opportunities of farmers.

It has long been obvious that better inputs and techniques are necessary to gains in agricultural productivity. New forms of capital--

including machines, roads, irrigation structures, and storage facilities--are also necessary. But the availability of superior seeds, fertilizers, pesticides, and animals, along with the other forms of new capital, is not sufficient to achieve large increases in agricultural productivity. Because of wrong incentives the real economic potential of agriculture is not being realized.

Land and farm people have their limitations. The productivity of farm land could be enhanced by investment; and its distribution by size of farms, as well as the prevailing tenure practices, could also be improved. Then, too, the health and schooling of farm people are below par. But despite these limitation, land and farm people are not the cause of the pervasive economic disequilibrium that characterizes the agriculture of low-income countries.

Since the early fifties there has been real progress in scientific agricultural research oriented to the requirements of poor countries. But the utilization of the contributions of this research is being seriously thwarted by the distortion of producer incentives. Accordingly, although more agricultural research is clearly warranted, it is presently not the major limiting factor in the production possibilities in many low-income countries. Meanwhile, large sums of external capital are being made available to such countries for agricultural development. The effective utilization of this capital is also being thwarted by the distorted incentives in agriculture. Thus, having achieved real progress in agricultural research along with considerable additional capital for agricultural development, the primary constraint that presently accounts for the persistent disequilibrium, which is revealed in the low productivity of agriculture in many low-income countries, is predominantly the lack of optimum incentives available to farmers.

In bringing economic analysis to bear on this problem, there are three key issues: the value judgments implicit in economics; an understanding of the reasons why governments treat agriculture as they do; and a general assessment of the agricultural production consequences of governmental policies. I shall consider these issues in turn.

On Value Judgments

When an economist is advising governments, and especially those of different countries than the adviser's, he must take account of national social values which may be expressed in national policies--regardless of economic consequences. The easy road for economists is to accomodate the purposes of government by assuming that all its current actions represent society's true values (rather than a potentially fallible mixture) or, for that matter, to embrace and justify

any of the various internal special political interest groups. But to proceed on this road reduces greatly the utility of economics. This fact is obvious in the case of interest groups. Although corporations, labor unions, farm organizations, and consumer advocates perform useful functions, they are not innocent economic agents, for they do conspire to exact benefits for themselves at the expenses of others in the economy. Clearly, when economics is used to serve special interest organizations, it sells economic analysis short. When economists merely accomodate governments, they serve only to rationalize what is being done and lose their potential as educators; they become "yes-men" in the halls of political economy.

The analytical core of economics is sufficiently strong to estimate the production effects of incentives and to evaluate the losses in income that are a consequence of distorted incentives. Furthermore, the costs and the personal income effects of welfare programs can also be estimated and evaluated. An example of an analytical approach is as follows. The costs of improvements in nutrition and in health that the poorest of the urban families achieve as a result of the "fair price shops" established by some governments can be ascertained. If the food for this purpose is acquired by the government by procuring food grains from farmers below market prices, the adverse effect on agricultural production is a part of the implicit costs of providing food for the "fair price shops." However small or large the real costs of providing food grains for shops, there are also alternative approaches to reduce the inequality in the distribution of personal income. Whether the alternative approaches are less costly relative to benefits needs to be determined. Only after such an exploration of the alternatives can policymakers apply their value judgments realistically.

Why Many Governments Undervalue Agriculture

It is not cynical to say that governments do what they deem necessary to survive. The individuals who govern are politically dependent on the support of particular population groups that make the regime viable. Economic policies are in this context a means to maintain political support. On the policies that are pursued, there is no lack of rationalizations by those in charge of the government and by the theoreticians that serve them. It is debatable how much governments learn from their mistakes, but certainly they are slow learners compared to farmers' ability to learn from their experience. All too little attention has been given to the factors that determine the learning function of governments.

Even though the rural population in low-income countries is much the larger, the "political market place" strongly favors the urban population at the direct expense of rural people. Politically, urban

consumers and industry demand cheap food. Accordingly, it is more important politically to provide cheap rice in Bangkok than to provide optimum price incentives for rice farmers in Thailand, for example. For Thailand it is an easy policy to administer; as long as the country has an exportable rice surplus, an export tax on rice suffices. This tax has the additional political advantage of producing revenue for the government. Export taxes to acquire public revenue are more indirect in the case of state marketing boards. Before the end of colonialism, state marketing boards were launched on the assumption that they would be an efficient way to stabilize the agricultural prices of major export producers, especially throughout Subsaharan Africa. But they were soon transformed into internal revenue agencies. Having been vested with monopoly powers, they proceed to pay a low price to farmers and then to sell the product at the higher export market price. Revenue thus is forthcoming, until the producer disincentives reduce production to the point where there is no exportable surplus.

The undervaluation of agriculture by governments is still being rationalized by an array of arguments that include the colonial heritage, the backwardness of agriculture, and its presumed low estate in contributing to economic growth. Agriculture in many low-income countries carries the stigma of having been the supplier of raw materials and of some food products that served the economic interest of the colonial powers. The view is still widely held that agriculture is inherently a backward sector; the presumption is that rural people resist modernization--notwithstanding the occasional small "green revolutions." From the point of view of those who manage the political sphere, the lowly cultivator is viewed as indifferent to economic incentives because it is presumed that he is strongly committed to his traditional low level of productivity. Thus, the stage is set for the doctrine that industrialization is the mainspring of economic growth and economic policy is designed to give top priority to industry, and this includes keeping food grains cheap.

Still another reason, often cited, why governments of some low-income countries turn away from agriculture relates to the presumed adverse effects of international prices and trade. World market prices of agricultural products and inputs (e.g., fertilizers) have been unstable. It is true that the world-price events associated with World War I, the Great Depression, World War II, and the recent worldwide inflation, compounded by monopoly oil prices and the price effects of short crops, caused a great deal of economic instability. Much is also made of the long-run decline in the terms of trade of agricultural crops, but this decline in large measure reflects the relative decline in real costs of producing farm crops with improving technology. In the United States, for example, the relative prices of "all crops" declined by 40% between 1910 and 1972. Despite govern-

ment price supports and complementary farm programs to raise crop prices, the production effects of the decline in real costs could not be stayed.

Currently, various arguments are advanced on behalf of welfare considerations with the implication that economic efficiency in agricultural production is at many points inconsistent with the welfare of the population. This concept of welfare has been imported from high-income countries. It is characterized by progressive income taxes, with a substantial part of the income from them allocated to low-income people as income transfers. What these high-income countries do in collecting public revenue and making income transfers is a far cry from the procurement of food grains from low-income farmers to supply urban "fair-price shops" and by this means subsidizing consumers at the expense of agriculture.

Moreover, the adoption and efficient use of new high-yielding seed varieties is not necessarily inconsistent with gains in the welfare of small farmers. Sample studies show that between 1966 and 1972 small farmers were about as prompt as large farmers in adopting modern rice varieties in various parts of Asia, and in profiting from the adoption. The presumed trade-off between efficiency in production and the welfare gains of small farmers in modernizing agriculture is therefore subject to serious doubts.

The most compelling reason why government interventions adverse to agriculture become more serious over time arises out of the fact that the economic effects of any major intervention call for additional interventions. One control leads to more controls, and as a consequence governments become increasingly enmeshed in administering the economic affairs of agriculture. As a rule this process begins on the convenient premise that a market-oriented economy is inherently inefficient in achieving economic growth. The presumption is that the market is most inefficient in providing the necessary inducements for rapid domestic industrialization. The curtailment of imports of industrial products protects the infant industries. The import substitution that this entails, however, increases internal prices, including those that farm people pay for industrial goods. The growth of infant industries is also affected by the level of wages, and real wages in turn are strongly affected by the price of food. In the short run cheap food can be had by reducing the internal prices that are paid to farmers, and by importing food grains.

Further enmeshment of governments in agriculture becomes the order of the day. The market is deemed to be inefficient in producing and distributing the new seeds of the high-yielding varieties of crops, and the government proceeds to nationalize this activity. The established private agricultural marketing system is viewed as the cause of

regional and of specific urban food shortages; again, as occurred in India, the solution chosen is to nationalize these markets. Elsewhere, additional state marketing boards have been established to replace the private agricultural markets, as in Kenya. When it becomes evident that farmers are curtailing their use of fertilizer for lack of incentives, governments, instead of allowing the prices received by farmers to rise, resort to subsidizing fertilizers and thereby become even more enmeshed in administering agricultural prices.

Production Consequences of Undervaluing Agriculture

The effects of weather aside, the normal annual, peacetime production of the world's agriculture is remarkably stable. It is much more stable than industry, with its business cycles, its abrupt declines in plant utilization and the associated unemployment. This secular stability of agriculture is a clue to the fact that large, quick increases in total agricultural productivity are not possible. Even under the best of circumstances, it takes more than a year or two to complete particular types of capacity-increasing investments. These simply cannot be had on short notice. Annual purchases of fertilizer and of other currently acquired inputs will not suffice to enlarge the aggregate productive capacity of agriculture. Shifts among crops in response to a marked increase in the price of a particular agricultural product relative to other products that are close substitutes in production are often large in one or two years. But agricultural production as a whole cannot be increased that quickly.

Substantial additional agricultural capacity requires two important time-consuming steps. There will be lags on the part of farmers in deciding that an improvement in incentives is not transitory. Sufficient confidence to undertake the required investment may not come readily in many low-income countries, even after policy is changed for the better, because of bad past experiences. The next step consists of undertaking and completing various intermediate and long-term investments that will enhance the capacity of agriculture. These steps are both necessary in the modernization of agriculture. There are no short cuts. Quick modernization is a will-o'-the-wisp. Optimum incentives for only a couple of years will not suffice.

It is no secret in economics that there is an important difference between the behavior over time of the demand for food and of the supply of agricultural products. As economic growth and agricultural modernization occur over time, the demand increases, mainly because of rising family income and population growth. The demand for food in low-income countries is a good deal more elastic than that in high-income countries. The supply curve, however, is more complex. During any short period it is highly inelastic, that is, the percentage change in prices is much larger than the percentage change in production it brings about.

But economic history tells us clearly that over time, as modernization takes place, the supply responses to price changes become much greater. The real price of most farm products declines as a consequence of reductions in the costs of production. A considerable part of the real welfare gains over time is accounted for by reductions in costs of agricultural production. Herein lies the prospect for substantial welfare gains in low-income countries during the next several decades.

The chain of actions and interactions to improvements in incentives is long and complex. It includes: (1) activities of agricultural research enterprises; (2) response of farmers in adopting the worthwhile output of that research; (3) price of capital and its efficient allocation in increasing the physical and biological capacity of agriculture; (4) quality of the stock of human capital, mainly from schooling and health of farm people; (5) efficient markets for agricultural products and for the inputs that farmers purchase; and (6) use of public funds to subsidize the food grains that are made available to those in the population who are deemed to be too poor to pay open-market prices. Currently, however, this agricultural chain is not in good shape.

The distortion of agricultural prices affects the adoption of the research output and this in turn affects the research agenda. Price distortion, therefore, tends to misguide agricultural research. Overvalued products receive unwarranted attention, and all too few resources are allocated to research of the undervalued products. National agricultural research is more directly subject to the implied misallocation of research resources than that at international research centers, but even the latter are not immune. Moreover, it is noteworthy that governments that undervalue agriculture have a propensity to treat agricultural scientists as high-class clerks.

Sugar beets are vastly overvalued in the high-income countries that have temperate climates, as already noted. As a consequence, far too much research is devoted to sugar beets. When the agricultural product is overpriced, research workers are misled on the returns to the national economy from their contributions to that product.

In terms of the food supply over much of the world, the general undervaluing of agricultural products reduces the potential returns to agricultural research. The resulting adverse effects on the relevant research enterprises are not to be dismissed lightly. All too little research has been undertaken on high-yielding wheat varieties in the Argentine as a consequence of distortion of wheat and fertilizer prices. In Colombia, research on wheat started early and new local varieties did even better than Mexican wheats. Nevertheless, the acreage devoted to wheat fell sharply from 1953 to 1973, in large part because of the importation of cheap P.L.-480 wheat; the resources

allocated to Colombia wheat research, in 1972 prices, were cut by half between 1967 and 1973.

Incentives to produce rice, the principal food crop throughout much of South Asia, are low because it is much underpriced by many governments. Although rice research in India has been going on for decades, fertilizer-responsive varieties were long neglected; the prevailing overpriced fertilizer and the underpriced paddy continue to confront the rice research enterprises with discouraging price signals. Agricultural research endeavors throughout much of central Africa are even more disoriented than in Asia by the economic disarray of agriculture.

The process of increasing the productive capacity of agriculture requires not only the inputs that embody the output of research but also various forms of complementary capital. Many excellent studies are now available on the adoption by farmers of new and more productive inputs resulting from research, but unfortunately studies of the functioning of the capital markets that serve farmers in low income countries are at best mainly descriptive. Rice, among the annual crops, and tree crops require more complementary forms of capital than most other crops before it becomes profitable for farmers to adopt the superior varieties presently available. The underpricing of farm products seriously thwarts both the optimum use of capital and the adoption rate.

One thing, however, is clear. Wherever the farm product is underpriced, even though superior varieties are at hand, the adoption is at best only partial. The British palm research center in Nigeria developed varieties of palms that are much more productive than the native palms. But few Nigerian farmers could afford to plant and bring the better varieties to fruition, mainly because the state marketing board seriously reduced the price that producers receive for palm fruits. The benefits from the research of the Nigerian palm research center were realized, however, in West Malaysia where the producers of palm fruits were not exploited by a government monopoly vested in a marketing board.

Concluding Remarks

When the political authorities suppress the entrepreneurial role of farmers, countries cannot succeed in modernizing agriculture efficiently. Political prices cut two ways. In a number of high-income countries farm products are overpriced and food is dear. In many low-income countries food is kept cheap at the expense of farmers and there are food shortages, and such pricing forecloses the possibility of production of food more cheaply over time. In such low-income countries

more and cheaper food will only be forthcoming when it is profitable for farmers to modernize agriculture.

The profitability and success of agriculture in many low-income countries are much impaired by governments. When exports and imports are restricted, agricultural prices call forth uneconomic production. When state marketing boards are granted a monopoly, the prospects for agriculture become dim. When governments authorize the procurement of food grains from farmers, the incentives to invest and to adopt superior varieties and techniques are impaired. When the welfare costs of "fair-price shops" are not financed by the government but are borne by agriculture, the full welfare gains from agricultural modernization are not to be had. Lastly, when ministers of agriculture treat agricultural scientists unfavorably, the agricultural research enterprises become stagnant.

Incentives do matter. The potential large increases in agricultural production in many low-income countries cannot be realized as long as farm entrepreneurs are confronted by wrong incentives.

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Food Pricing Policies in Developing Countries

P. L. Scandizzo and I. Tsakok

[Several important Asian countries operate relatively large scale efforts to supply cheap food to the poor--in most cases urban. The costs and benefits and special problems this entails are analyzed.]

Food has been an important object of government intervention policies in all societies since the inception of the market exchange system. In fact, as documented by anthropology, food rationing and food distribution have been fundamental concerns of most primitive societies, and their regulation is generally a prerogative of the highest authority of the tribe or the village.

The reasons why governments find it necessary to intervene in the markets for food can be grouped under the three heads: (i) equity, (ii) efficiency, and (iii) economic strategy. Social standards typically require that a minimum amount of food be available for everyone, or that provisions be made to transfer at least some food from the surplus households to the deficit units in the population. Governments also intervene in an effort to speed modernization of agriculture. In addition, developing countries have largely used direct or indirect pricing policies in attempts to influence the patterns of growth of their domestic economies. Agriculture and food production have been used as a primary source of both government revenues and indirect transfers to the emerging secondary and tertiary sectors.

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There are several good reasons for this attention to agriculture. First, the agricultural sector is typically the only one where a sizeable surplus is produced in a primitive society. As this surplus has to be traded with the rest of the world, the government finds it relatively easy to tax, or to monopolize trade and retain part of the foreign exchange earnings. Second, the sensitivity of agricultural production to the taxes imposed on it does not appear to be very high provided they are in a reasonable range and concern only the marketable surplus. Third, the capacity of farmers to organize themselves to "raise hell" and upset politicians grows only slowly in comparison with that of industrial workers and the urban masses.

A rationalization of government taxation policies toward agriculture was provided by the so-called transformation theory: accelerated industrialization was a desirable goal for a developing country, but such a goal could be achieved only by transferring surplus from agriculture to industry and, at the same time, by protecting the "infant" industrial sector from external competition. Taxation policies toward agriculture therefore often became predatory, not only in the sense that direct transfers to non-agricultural sectors were huge, but also because the combination of explicit taxes and overvalued exchange rates distorted the terms of trade to the point that no incentive was left to producers to innovate and invest in agriculture.

In general, unless other sources of revenue and/or surplus can be found in the economy, developing countries aggressively tax and "anti-protect" agriculture. Countries with large mineral resources, such as the oil producing countries, would seem to be in no need of exploiting their agricultural sectors in that way. Even in these cases, however, unfavorable circumstances for agriculture are generated by the rapid growth of the urban economy that generally accompanies the accelerated exploitation of mineral wealth. Income growth in urban areas tends to fuel wage increases in agriculture, and leads to huge import bills. As the ensuing inflation is typically not met by devaluation, since the currency is strong because of the mineral revenues, the overvaluation of the currency and the induced scarcity of labor act as an implicit tax against agriculture.

On the consumption side, developing countries with almost no exception tend to favor urban consumers. Subsidies to food consumption in the cities take various forms, ranging from rationing or fair price shops where limited quantities of food are sold at subsidized prices (India, Pakistan, China) and food stamps programs (Sri Lanka) to generalized price subsidies (Egypt, Turkey). For the same reasons that agricultural taxation is widespread and heavy, concern for consumers only rarely extends from the cities to the rural areas. Sometimes the impact of food subsidization may be positive in rural areas, especially in the vicinity of urban centers and for landless workers.

In many developing countries, however, the policy of forced transfer of surplus from agriculture to the rest of the economy tends to create a nutritional problem in the rural areas where food scarcity results from inadequacy of the market mechanism. Four basic situations are: (i) a chronic shortage of food because of long term deterioration of the population/food supply balance; (ii) a temporary shortage because of severe droughts, or other causes of crop failure; (iii) recurrent shortages of food because of highly seasonal production patterns, such as periodic droughts or floods; and (iv) a sharp loss of purchasing power or other ways of securing food entitlements by portions of the rural population.

Deterioration of the population/food supply balance appears to be a major problem for sub-Saharan Africa. Temporary shortages due to crop failures and highly seasonal production patterns are common features of the food supply/demand picture in many rural areas. Temporary food shortages for rural households are often caused by declines of real income, either because of a fall in employment and wages or because of price increases, or by the inadequacy of the delivery systems. Such shortages can be seen as a manifestation of rural poverty, and of inequality of income distribution, rather than of a physical shortfall of food.

Subsidized Food Consumption: Major Programs in Asia

The consumption of food has been subsidized either by (i) general subsidization, which occurs through the increase in domestic supply beyond the point that would have been reached in a free trade situation, or (ii) targetted subsidization, whereby the government makes a limited supply available to designated groups at below market prices. Targetted subsidization of basic foodstuffs on a continual basis through what has come to be called a ration system is not common worldwide, but it is present in major Asian countries: Bangladesh, India, Pakistan and Sri Lanka in South Asia; Indonesia and the People's Republic of China in East Asia. Burma (not discussed here) operates a large-scale ration system. In South Asia, these targetted subsidy systems originated in the 1940s as a response to war-related shortages and are now the major channels by which basic foodgrains are procured, both from local producers and abroad, for distribution at politically acceptable prices in larger population centers. The term ration is used here because although additional quantities of the subsidized commodities are available on the open market at high market-clearing prices, only limited quantities are available at low ration prices. Indonesia maintains a general subsidization of rice; China subsidizes only urban residents, the precise group of beneficiaries depending on the definition of "urban" which has varied since 1949.

This targetting, explicit and implicit, of food subsidies varies from country to country as a function of the choice of subsidized foodstuffs, eligibility criteria, purchasing conditions and the selection of ration shop locations. In Sri Lanka, only income taxpayers (not more than 1% of the population) were officially excluded from the rationing system, and unlike in other countries rationing has very effectively covered the poor and rural areas. (This has changed since 1977 and now only the poorest half of the population is included in the rationing system.) The basic rice ration has generally stayed between two and four lbs/person/week, with one or two lbs provided free of charge and the remainder sold at highly subsidized prices. Wheat flour has also been rationed.

In India, wheat, rice and small quantities of coarse grain are sold in ration or "fair price shops." Subsidized distribution is concentrated in the cities, mainly Bombay and Calcutta, and even in cases of formal rationing where ration books are supposedly issued on the basis of need, everyone appears to have easy access to fair price shops. However, most of the people familiar with the system feel that the location of fair price shops, the long waits in lines, limits on the quantities available at any time, and the inferior quality of rationed grains means that in practice only poorer groups take significant advantage of the ration system.

The rationing system in Bangladesh can be divided into (i) statutory rationing, (ii) modified rationing, (iii) relief, and (iv) special coverage of selected groups such as government employees and industrial workers. Statutory rationing, which exists in six urban areas, is based on the premise that each resident is to have a ration card which entitles him to purchase at low prices a certain amount of rice and wheat each week. Ration shops are not necessarily located in poorer neighborhoods, and the system has become sujected to a number of abuses such as phony ration cards and black markets. "Modified rationing", which exists outside of urban areas and accounts for not more than 30% of total ration throughput, provides a bi-monthly ration at low prices generally only to families who pay no taxes. Relief rationing is on an *ad hoc* basis; special coverage rationing is only extended to institutions outside statutory rationing areas. Therefore, except for the modified and relief rationing (and the use of some wheat which is less acceptable than rice in higher-income diets), the rationing system in Bangladesh is not targetted toward the poor.

In Pakistan, whole wheat flour is subject to provisioning. This means that all consumers are entitled to purchase a limited quantity at low prices from the ration shop. Actual use of that wheat ration is limited by a variety of factors, such as the preference for rice and the fact that ration shops in rural areas are open only several days per month; customers may not have enough cash to purchase their

entire monthly quota at this time. Nonetheless, the system in Pakistan is probably more accessible than elsewhere except for Sri Lanka, as it is rare in Pakistan for shops to deplete their supplies completely, and prices are relatively low; due to the overstatement of family members, the number of registered recipients exceeds the actual population.

The ration systems are large in scale in all four countries. As can be seen in Table 1, they handle from 15% (Bangladesh and India) to over 50% (Sri Lanka) of total consumption of wheat and/or rice. If subsistence consumption is excluded, the percentage of total marketable consumption distributed through these systems is much higher, ranging from about 40% (India) to over 80% (Sri Lanka). The combination of high output and low ration prices (they are usually maintained at less than 50% of open market prices) has implied a considerable degree of subsidization.

In all these countries, part of the heavy burden of price subsidization has been shifted onto producers through the use of controlled procurement at low prices and/or trade regulations, which helps to keep producer prices below world levels. In addition, all the countries are frequent recipients of concessionary aid. India and Pakistan attempt to limit budgetary expenditures to administrative overhead and possible losses on non-concessionary imports by setting ration prices that cover general procurement costs plus variable administative expenses. Price subsidy schemes have been officially absorbing over 5% of budgetary funds in Bangladesh and Pakistan, and over 15% in Sri Lanka.

In Indonesia, the general subsidization of rice is implemented through BULOG, a government agency which operates large buffer stocks based on rice imports and also provides rice in kind to the military, civil servants and employees of state-owned enterprises. BULOG is expected to inject milled rice into the open market at below-market prices whenever prices rise above a predetermined ceiling, thereby preventing market prices from reaching world levels in periods of high world prices. This general subsidization of rice thus occurs only when world prices are high; the operation may be partially financed by general taxation when world prices are low since BULOG can then market imported rice at above world prices.

In China, urban residents who have access to ration cards receive State-procured rice, wheat, edible oil and salt. Non-food items, namely cotton cloth, household coal and common medicines are also subsidized. When the Communist government gained power in 1949, China was in the grip of hyper-inflation. The maintenance of price stability and the guarantee of basic foodstuffs at stable and affordable prices have since been considered of utmost importance in promoting the regime's legitimacy and support for its economic and socialist

Table 1

Data on the Extent and Cost of Ration Systems

		Ration Price as % of Open Market Price	Quantity Rationed as % of Total Consumption	Quantity Rationed as % of Total Non-subsistence Consumption	Fiscal Cost of Subsidy to the Economy: Per Capita Cost	Govt's Share of Cost	Producer's Share of Cost	Budgetary Cost as % of Total Expenditure 1/
		(%)			(US$)	(%)		(%)
Sri Lanka	1974	n.a.	46	85-95	15.01	68	32	17
	1975	n.a.	54	85-95	10.14	87	13	16
	1976	n.a.	53	85-95	7.02	89	11	n.a.
India	1974	47	15	38	7.88	10	90	n.a.
	1975	47	18	44	4.22	20	80	n.a.
	1976	60	13	36	3.54	10	90	n.a.
Pakistan	1974/75	44	32	78	7.19	24	76	13
	1975/76	55	27	60	7.34	45	55	11
	1976/77	51	33	80	5.03	36	64	n.a.
Bangladesh	1974/75	19	15	56	1.55	230	-130	11
	1975/76	37	13	56	2.98	94	6	8
	1976/77	50	12	52	3.48	50	50	n.a.

1/ For Pakistan and Bangladesh the cost estimate refers to the calendar year with the 1974 estimate appearing under 1974/75.
2/ n.a.: not estimated

programs. In the 1950s, the State initiated its monopoly control over the purchase and marketing of all major farm products while the collectivization of agriculture and the public ownership of industry were proceeding apace. The state also has monopoly control over foreign trade, including grain imports. In the 1950s, agriculture was taxed to provide cheap food to the cities, but state procurement and resale were quite profitable. In the 1960s, however, and increasingly in the late 1970s, as agricultural procurement prices were raised to promote producer incentives, state trading has incurred significant losses which required increasing budgetary transfers.

The beneficiaries of these subsidization programs are estimated at 100 million in 1955 (or 15% of China's population) and at 102 million in 1975. China's population increased by roughly 1.9% a year during this period; however the rate of urbanization declined. Numbers of urban residents did increase, but this stagnant beneficiary total indicates that increasing numbers do not benefit from state procurement and subsidies. In general, rations are considered to have been adequate, with black markets being significant only in particularly lean times, such as the Great Leap Forward, 1958-60. Over the years wheat imports have increased, allowing rural areas to retain more of their production. In spite of the increasing budgetary burden generated by urban subsidies--they absorbed 22% of the state budget by 1981--there is no indication that a major restructuring is currently envisaged.

The Rationale for Market Intervention

Three sets of reasons can be distinguished for existing or new market intervention policies: (i) explicit government objectives, (ii) rationalizations, and (iii) benefits for some of the social groups affected. These three categories are not mutually exclusive and in most cases are indeed overlapping. What may be seen as an explicit objective by the government may be an attempt to provide an objective rationale for a policy that the government is forced to pursue under the pressure of a socioeconomic group which benefits from it. Nevertheless, it is important to maintain these distinctions since both the rationale of the intervention and what can be done about modifying or removing it will depend on the weight of these three categories.

The chief justification for market intervention in most developing countries is the provision of food at affordable prices to the poor. This is stated as an explicit government objective in countries as diverse as Egypt, Turkey, Sri Lanka, Bangladesh, India, Pakistan, Indonesia, and China. It is considered a component of an income transfer mechanism operated by the government.

In its historical origin, the present system of food provision at lower-than-market prices originated in most cases as a response to shortages and famines caused by wars. However, because of the large bureaucracies and numbers of beneficiaries that were created, governments have found it very difficult to abolish or greatly modify the structures set up during these tormented periods, even when most or all the causes of their inception had disappeared. As one consequence, food subsidies or income transfers based on food tend to be biased in favor of the urban population, and even within the cities are not necessarily directed toward the poor, whereas the rural poor (usually a majority of those in poverty) tend to be left out. The poverty orientation of food subsidies is thus in part a rationalization of policies which are too difficult to change because of implicit or explicit beneficiary pressures. Beneficiaries include all the groups directly receiving subsidies such as the urban poor, the bureaucrats, and the portion of the middle class with access to the system. They also include groups who benefit indirectly, such as employers who in effect receive a subsidy on the wages they pay to laborers; and food importers, wholesalers and retailers who also benefit from an indirect subsidy due to the expansion of consumers' purchasing power.

Evaluating Intervention Policies--the Practical Setting

Asian food subsidy programs have generally been effective in protecting urban consumption. The scope of these programs varies from just basic grains to including vegetable oil, sugar, selected livestock products and cotton cloth. The poorer the country, the more important these programs tend to be, as in China and South Asia. These programs reflect the importance of the urban sector to governments. Governments have viewed industrialization as the cornerstone to growth; hence the concern for the urban sector. In addition, the urban sector tends to be organized; hence governments are more vulnerable and responsive to its needs. Humanitarian considerations also enter. Unlike the rural poor who can in most cases grow their own food, the urban poor must have their basic food supplies guaranteed.

The adequacy of these food distribution programs in improving the nutritional status of intended beneficiaries has varied depending, among other things, on initial levels of severity of malnutrition, complementary health-improving programs, and cultural factors. China is well known for its success in eliminating acute and widespread malnutrition. Given the strong urban bias of its programs, however, and for years its policy of regional self-sufficiency, malnutrition is still serious in certain rural areas of low grain producing regions. Urban consumption of both cereals and meat exceeds rural levels. The rice ration (1979) meets 65% of energy requirements

and 70% of protein requirements (using the FAO yardstick); the wheat ration, 58% and 99% respectively.

Analysis of the food distribution system in India and its neighbors indicates positive net social benefits on the assumption that there is reasonable social concern for minimum food consumption of the poor. Analysis of the impact of intervention through ration systems in the major South Asian countries indicates that these systems eliminated 16% to 59% of the nutrition gap. However, the impact is still not adequate in view of the severity of malnutrition. Except for Sri Lanka, the poorest 40% consume less than 85% of minimum daily requirements. In Indonesia, the poorest 40% consume only 75% of this minimum, and intervention eliminated 7% to 43% of the gap depending on the year.

The costs of these programs, however, are a major concern. The financial costs are borne by rural producers in the form of lower net earnings, and by taxpayers through budgetary transfers. In poorer countries, where these programs are more meaningful socially and politically, the ability of producers and goverments to shoulder these costs is also less. Therefore, precisely where it would be most desirable to retrench from an incentive and fiscal point of view, it is difficult or undesirable to do so from a political or a humanitarian point of view. Recently, the Government of Egypt withdrew flour subsidies, but was soon forced to grant them again as riots broke out. The Chinese government has recently reiterated its commitment to the subsidization program, despite the increasing budgetary burden it entails. The fear is both of inflation and political instability.

There is, however, scope for restructuring these programs to benefit production and fiscal balance without causing unbearable hardships to the really needy. The experience in Sri Lanka since 1977 is instructive. Since 1948, Sri Lanka had maintained an extensive program to benefit urban and rural areas, which absorbed on average 15% of budgetary revenues. In 1977, the program was made much more selective: food stamps were given to only those below a certain income level. At the same time, economic reforms succeeded in increasing investment, employment and hence incomes and purchasing power. The substantial increases in purchasing power thus enabled the Government to reduce food subsidization without threatening the stability of the whole system. Inflation was high in the initial years, roughly 35% a year, but by 1981 it had been reduced to about 14%. The key to this successful transition seems to have been the substantial growth in private investment and purchasing power.

Burdensome as the financial costs of food programs may be, they still understate the total costs of these programs to the economy.

The longer run economic costs arise out of (1) a slackening of agricultural growth as substantial producers' incomes are transferred to consumers, thus weakening producer incentives; and (2) an increased share of scarce government revenues going into consumption rather than investment to promote longer term growth. Some estimates have been made to quantify potential production losses. In Pakistan, the combined effect of consumer subsidies and producer taxation on wheat resulted in substantial imports, although Pakistan has the potential of being a net exporter. Thus, although Pakistan has been maintaining wheat self-sufficiency as a stated policy objective, the actual impact of market intervention has been to undermine its achievement. There is thus a sharp divergence between intended and unintended consequences of policy.

In sum, the welfare aspects of intervention present a complex pattern of benefits and costs. Urban consumers benefit, as does the industrial sector as a whole through cheaper labor. There are also beneficial health and productivity effects. Producers and taxpayers bear the major costs of these programs. However, the economy as a whole can suffer as production incentives weaken, or productive investment opportunities have to be sacrificed. Given this complexity, it is understandable that governments typically show little flexibility in restructuring intervention. This limited flexibility is reinforced by the network of power and patronage which any system of government intervention generates.

Intervention must be implemented by various institutions which are costly to operate. The more extensive and intricate the intervention, the more complex the institutional superstructure tends to become. In socialist economies, the public sector is involved not only in enforcing prices, quotas and regulations, but also in marketing, processing and retail sales. In mixed market economies where the private sector is allowed freer play, the public sector can still be extensive, as in many African countries. Public institutions are often required to pursue conflicting goals--for example, buy dear from the farmer and sell cheap to the consumer. They are often also required to operate within tight financial and staff constraints. Yet because they are essentially bureaucracies and monopolies, they are not subject to the discipline of competition. These institutions therefore typically exhibit a combination of power and weakness, or corruption and inefficiency. The extent to which their performance can be substantially improved is a source of continuing debate.

Despite their shortcomings, their elimination or reform is likely to meet with stiff resistance. They do serve important group interests, including their own survival. They may help maintain a system of political compromise, and thus stability which is useful

for enabling progress on other fronts. The issue therefore is not only their administrative costs *per se*, but whether they help enforce a system of incentives, decision-making and income transfer which, aside from benefitting specific groups, also promotes the interests of society as a whole in its pursuit of growth and social justice. And it is necessary to distinguish short run from long run results--for example, feeding some of the urban poor today at the expense of potential food supplies for the urban and rural poor at some future date.

[Extracted from Food Pricing Policies in Developing Countries, AGREP Division Working Paper No. 46, World Bank, Washington, D.C., 1982. (AGREP is the Economics and Policy Division of the Agriculture and Rural Development Department.)]

Note: The views expressed here are not necessarily those of the World Bank.

The Political Economy of Rice Production In East Asia

C. Peter Timmer and Walter P. Falcon

[This article indicates the key importance of rice and fertilizer prices in shaping the trends in output and yields per hectare for the basic food staple of millions of people in much of Asia.]

The International Rice Economy in Perspective

Table 1 provides an array of statistics on the quantitative role of rice in Asia. Per capita domestic disappearance levels, approximately equal to direct personal consumption (except in regions where significant quantities are used for animal feed), are remarkably different for similarly situated countries and remarkably similar for vastly different ones. The levels in Laos, the Khmer Republic (Cambodia), Thailand, and Burma are nearly double the West Malaysia level. And yet Japan and Indonesia have almost identical per capita consumption. China, India, and the Philippines have similar but significantly lower levels, reflecting alternative sources of carbohydrates in these diets.

The yield data show a widely ranging distribution from a low of 1.70 metric tons per hectare in Burma to a high of 5.64 tons in Japan. The three highest yields occur in Japan, South Korea, and Taiwan, which have some of the poorest soils among these Asian countries. The success of these countries derives from greater environmental control, especially of water; from differential use of inputs, such as fertilizers and high-yielding varieties; and from temperate patterns of rainfall and sunshine.

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Table 1: Comparative Country Data on Rice, 1970

Country	*Production (1,000 metric tons, rough)*	*Area (1,000 ha.)*	*Yield (tons per ha.)*	*Domestic disappearance per capita (kg. milled rice)*	*Proportion of area in new varieties*
Burma	8,162	4,809	1.70	174.1[a]	4.0
Ceylon	1,616	611	2.65	124.5	4.5
China, Mainland	102,000	—[b]	3.05	88.4	—
India	63,672	37,432	1.70	77.7	14.7
Indonesia	17,529	8,186	2.14	104.3	11.3
Japan	16,479	2,923	5.64	102.9	—
Cambodia	3,814	2,399	1.59	265.2[a,c]	—
Korea, South	5,476	1,209	4.55	139.1	—
Laos	916	670	1.37	215.2[a]	7.0
Malaysia, West	1,429	525	2.72	130.1	24.5
Pakistan	20,014	11,416	1.75	115.8	41.7[d]
Philippines	5,343	3,113	1.72	93.3	50.3
Taiwan	3,226	776	4.16	149.8	—
Thailand	13,270	6,727	1.97	218.5[a]	2.1
Vietnam, North	5,000	2,500	2.0	156.7	—
Vietnam, South	5,716	2,510	2.28	238.1[a]	19.3
United States	3,758	734	5.12	3.9	—

a. Domestic disappearance levels for the delta countries of Indochina include very substantial amounts of rice used as animal feed. For estimates of magnitudes for the Mekong Delta in South Vietnam, see Richard J. Foote, "Supply and Utilization Tables for Rice and Implications for Policy and Research: Final Report" (Saigon: United States, Agency for International Development, December-January 1971–72).

b. Not available.

c. 1969–71 average.

d. West Pakistan only.

Sources: Data for area, production, and yield for all countries except Mainland China from Food and Agriculture Organization (FAO), *Production Yearbook 1971*. Mainland China yield from United States Department of Agriculture, *World Agriculture Production and Trade, Statistical Report* (Washington, D.C.: Government Printing Office, December 1971). Per capita consumption is calculated from production milled at 66 2/3 percent, plus or minus net trade from FAO, *Trade Yearbook 1971;* population from United Nations, *Demographic Yearbook*, and idem, *Monthly Bulletin of Statistics*, November 1972. Change of stocks for the United States, Japan, and the Philippines included; data for change of stocks from United States Department of Agriculture, *Foreign Agriculture*, (Washington, D.C.: Government Printing Office, February 1972), August 30, 1971. Proportion planted in high-yielding varieties from United States Department of Agriculture, *Imports and Plantings of High-Yielding Varieties of Wheat and Rice in the Less Developed Nations*, (Washington, D.C.: Government Printing Office, Feb. 1972).

Of all the contrasts among countries, however, perhaps the most striking is in prices. The differences in national rice prices, shown in Table 2, are so substantial that they would not be affected greatly by adjustments for inappropriate exchange rates or differences in quality and variety. Japan's price was nearly double South Korea's, the next highest price; nearly triple the prices in Taiwan and Ceylon; and seven times the Thai and Indonesian prices.

The ratio of rice price to fertilizer price, partly because it circumvents exchange rate problems and partly because of the element of input price, is an important reflection of the price climate facing farmers. These ratios for 1970 are also shown in Table 2 and the differences are even more pronounced than those for rice prices alone. Not only did Thai and Burmese farmers receive low prices for their rice, but they paid high prices for their fertilizer.

Table 2: Comparative Price Data for Fertilizer and Rice

Country	*Paddy price to producers (U.S. cents per kg.)*	*Price of fertilizer nutrients to producers (U.S. cents per kg.)*	*Ratio of paddy price to fertilizer price*	*Paddy yield in 1970 (m. tons per ha.)*
Japan	30.7	21.5[a]	1.428	5.64
South Korea	18.4	19.1	0.963	4.55
Taiwan	11.7[a]	26.2[a]	0.447	4.16
Malaysia	8.8	20.3[b]	0.433	2.72
Ceylon	11.3	15.8	0.715	2.64
Indonesia	4.5	15.2	0.296	2.14
Thailand	4.5[a,c]	14.3–50.0[d]	0.315–0.090	1.97
Philippines	7.0[e]	17.3[e]	0.405	1.72
Burma	3.1[f]	25.1[g]	0.124	1.70

a. Average for 1969/70 and 1970/71.

b. Calculated from *Padi Farming in West Malaysia*, Department of Agriculture, March 1972.

c. Calculated from the price of #2 paddy in Bangkok multiplied by 0.9 to get a producer price.

d. The fertilizer price is a price for ammonium phosphate in 1967. The lower price assumes both the nitrogen and P_2O_5 content contribute to increasing output; the higher price assumes only the nitrogen content is effective. All other fertilizer prices are for the nitrogen content of urea.

e. The producer price of paddy was P0.45 per kilogram and the nutrient cost of fertilizer was P1.111 per kilogram. The "fluctuating free exchange rate" of P6.43 = $1.00 was used for the conversion.

f. Figure for 1965. Trade reports indicate the paddy to fertilizer ratio improved by 1970, so a figure of 0.20 was used in the analysis.

g. Figure for 1969/70 only.

Sources: Paddy prices for South Korea, Indonesia, and the Philippines and the fertilizer nutrient price for Indonesia are from *Viewpoints on Rice Policy in Asia* (Los Banos: International Rice Research Institute, 1971). All other prices are from FAO, *Production Yearbook 1971*. In all cases attempts have been made to approximate prices actually faced by producers.

Rice Prices and Production

Explaining international trends in rice output and the prices at which it is traded is one goal of our model of the Southeast Asian rice economy. As a first step we estimate a cross-section production function for rice for the years 1962 to 1970. A production function containing rice area harvested and total fertilizer nutrients applied as the independent variables adequately explains the widely different levels of rice production in the eight countries examined: Japan, Thailand, Indonesia, Philippines, Malaysia, Taiwan, Sri Lanka, and South Korea.

The area devoted to rice culture in any country is a long-run policy variable, especially in terms of irrigation investment; but it has limited flexibility in the short run. Thus, for a given area, the emphasis must be on the factors that affect output in the short run, such as fertilizer. What is needed initially, therefore, is an empirical estimate of the aggregate fertilizer-yield relationship for this sample of countries.

[Editor's Summary. The determination of rice production in the eight Asian countries in 1962-70 may be very briefly described as follows. A simple regression making rice output (Q, in tonnes) a result of planted area (H, in hectares) and fertilizer applied (F, in kilograms) shows good results--see equation 1 in Table 3. Equation 2 is a more complicated one in which each country is permitted a separate intercept value based on its own unique ecological and policy setting, but all countries have the same fertilizer response; this equation explains over 99 percent of the variation in production. Equation 1 shows a coefficient fertilizer of 0.251, that is, a 10% increase in fertilizer applied results in a 2.5% increase in output--other things being equal. Equation 2 shows this coefficient at only 0.123, about half the value of equation 1. The authors consider that equation 1 gives a long run response relationship, and equation 2 a short run response.

Finally, equation 3 is an attempt to explain (in the same form as equation 1) the yields received by farmers in tonnes per hectare. It indicates that yields are largely determined by the amounts of fertilizer applied per hectare, explaining 71 percent of the variation.

Note: A great deal of technical material is omitted from this extract. Interested readers should consult the original, which also extends this model to explain imports and exports of rice and discusses a number of institutional and political factors bearing on rice and fertilizer pricing and policies.]

Table 3: Rice Production Functions, Seven Asian Countries, 1962-70

Equation No.		R^2
1.	$\log Q = -1.049 + .251 \log F + .867 \log H$ $(-3.2) \quad (12.4) \quad (32.6)$	.937
2.	$\log Q = (\text{various}) + .123 \log F + 1.202 \log H$ $(4.9) \quad (10.1)$	.995
3.	$\log Q/H = -1.049 + .251 \log F/H + .118 \log H$ $(-3.2) \quad (12.4) \quad (3.4)$	.708

Symbols:
- Q - Rice production (tonnes)
- F - Fertilizer applied (kilograms)
- H - Area planted (hectares)
- Q/H - Yields (tonnes per hectare)
- F/H - Rate of fertilizer application (kilograms per hectare)

Once it is established that yields depend on fertilizer application, the next question is whether fertilizer applications depend on the ratio of rice prices to fertilizer prices. There is sufficient evidence to believe that a given group of farmers in a particular country will probably respond to fertilizer price changes over time. But our question is different. Do farmers in different countries, when faced by different price ratios at a given point of time, use correspondingly different fertilizer levels? If they do, then the implications are that both the farmers and the basic rice production functions for this region are from a single universe.

That prices do matter is best seen in Figure 1, which plots the relative price of rice to fertilizer in 1970 for our sample of countries against the 1970 level of fertilizer application per hectare. The ordinary least squares estimate of this relationship (indicated by the solid line) shows that an increase in the price ratio of 0.1 leads to an extra 55 kilograms of nutrients per hectare. The startling statistic from this regression, however, is clearly the R^2 of 0.85. This says that 85 percent of the variation in fertilizer application per hectare observed in these nine Southeast and East Asian countries in 1970 was accounted for by the different price ratios of rice to fertilizer faced by their farmers. It seems that prices may be more important in the development process than many of us realized.

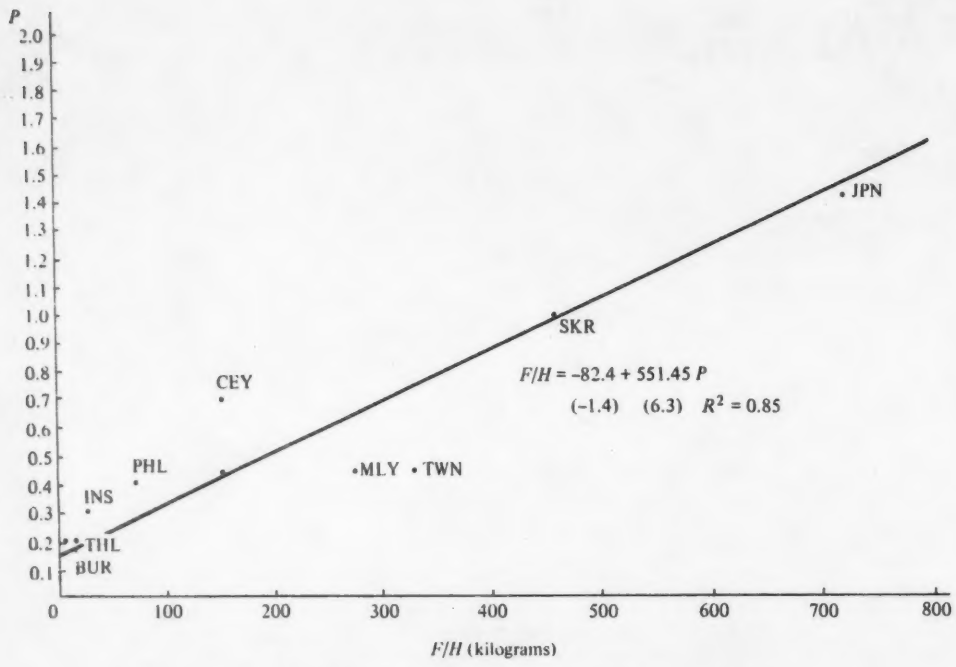

Fig. 1 Relationship of Relative Price of Rice to Fertilizer (P) and to Fertilizer Application per Hectare (F/H)

[Extracted from Chapter 14 of Agriculture in Development Theory, Lloyd G. Reynolds, editor. Copyright© 1975, Yale University Press, New Haven, Connecticut.]

SMALL-SCALE ENERGY

Small-Scale Renewable Energy

Andrew E. Rice, Associate Editor of the Development Digest

During the past decade the possibility of utilizing more renewable energy in the developing countries has received growing attention. Exploration of large-scale technologies primarily designed to replace petroleum in the modern sectors of their economies has been accompanied by investigation of small-scale energy sources aimed at increasing productivity and reducing costs at the local level, especially under rural conditions.

These small-scale approaches may be classified in two main categories: those which are principally useful in providing fuel for cooking, and those with wider applications in rural industry and agriculture. The first category includes ways of expanding traditional renewable energy sources, such as firewood and charcoal, as well as methods of improving the design of stoves to make them more efficient. It also includes newer technologies such as production of biogas. The second group of rural power technologies covers such methods as solar drying, photovoltaic conversion of solar energy into electricity, windmills and small hydroelectric plants. (For a brief but comprehensive survey of these technologies, see Renewable Energy Resources in the Developing Countries, World Bank, January 1981.)

The articles in this section of the Digest deal with both categories. A case study of biogas utilization in India is followed by a summary of the current "state of the art" for gasifiers, then by a survey of windpower options in a number of countries and finally by a more detailed examination of several technologies in use in rural China.

Lessons drawn from experience thus far--particularly with respect to relating the technical feasibility of a new technology to the economic and social conditions in which it is introduced--are treated in the next two selections. The final piece is a plea for more systematic research on the effectiveness of small-scale renewable energy.

Biogas Systems in India: Is the Technology Appropriate?

Jonathan B. Tucker

[Small biogas plants, fermenting dung and plant residues to produce gas for cooking and heating along with fertilizer, have much potential value for rural India. But only the richer villagers can afford to own them; and community units present problems. The technology may be made more appropriate to rural conditions by further research.]

Biogas Technology

A solution to the problems of rural energy and fertilizer in India (and elsewhere) may be the use of biogas generation. This technique involves the bacterial fermentation of cow dung and other organic wastes in the absence of oxygen to yield a mixture of about 30 percent carbon dioxide and 70 percent methane (natural gas). The mixture is combustible and can be used for heating, lighting, powering irrigation pumps, or generating electrical power for local use. Moreover, the energy yield from biogas is much greater than from burning dung directly as is very common in India; the energy efficiency of cow dung cakes is about 11 percent, compared to 60 percent for biogas.

The sludgelike residue that is left behind after the fermentation process has taken place contains all of the nitrogen, phosphorus, and potassium of the original material and hence makes an excellent organic fertilizer. Thus the process of anaerobic (oxygen-free) fermentation is able to extract much of the fuel value from animal and plant wastes without destroying their fertilizer value.

Jonathan B. Tucker, a free-lance journalist specializing in science and technology, recently returned from working in Somalia with CARE, Inc.

The advantage of biogas plants for rural energy production is that they can operate successfully on a small scale and utilize locally available inputs. The typical plant consists of two main components: a below-ground fermentation tank built of concrete blocks or of rocks and cement, and a steel dome to collect the biogas. Once the tank has been filled with slurry (a mixture of animal dung, water, and crop residues), the plant is sealed and its contents left to ferment for about 30 to 40 days. In the design currently widespread in India, the gas collector floats like a bell in the fermentation mix, serving both to collect the biogas and to prevent oxygen from reaching the slurry.

Once methane gas has accumulated in the collector, it can be extracted by drawing it through a hose into the farm kitchen, where it then can be used for lighting, space heating, or cooking with stove rings designed to function at low pressure. After the gas has been used up, the spent slurry--now called sludge--is pumped out of the fermenter and is carted to the fields for use as fertilizer. A fresh batch of slurry is then loaded into the fermenter and the digestion process begins anew. Farmers can also add crop residues, such as grass, straw, husks, and chaff, to help in the rapid composting of these agricultural wastes. In the biogas plant the process takes about three months, compared with the normal composting time of nine to twelve months. (This description is for a batch-fed digester which periodically stops producing and is then recharged. Another type operates continuously, with regular feedings of slurry and continuous production of gas and fertilizer.)

The fermentation process occurs in two steps. First aerobic (oxygen-dependent) bacteria in the tank digest the long cellulose molecules in the waste material, oxidizing them to acids and alcohols and thereby consuming the oxygen remaining in the tank. In the second, oxygen-free phase, methanogenic (methane-producing) bacteria convert these simpler molecules into methane and carbon dioxide. Since in the absence of oxygen there is relatively little free energy available to the bacteria, they multiply less rapidly than under conditions of ordinary aerobic decay.

Anaerobic fermentation requires a set of delicately balanced chemical and physical conditions. Changes in temperature, acidity, input mix, and other factors will affect the rate and yield of the microbiological reactions. For example, the methanogenic bacteria function best between 95 degrees and 100 degrees F. At 68 degrees, a pound of dry dung produces six cubic feet of biogas. Below this temperature, biogas production falls off, and at 50 degrees it stops entirely. Thus, in northern India, the usefulness of biogas plants is limited by the low ambient temperatures during the winter months--in spite of the large cattle populations in the region. It is therefore necessary to use some of the biogas to heat the digester to 70 degrees or above, thereby reducing the net yield.

Applications and Scenarios

Although the biogas technology had been known and used in a few prototype applications before World War II, it was not made a part of the development plans of the 1950s and 1960s. In the mid-1970s, the shock of the oil crisis led the Indian government to a belated recognition of the value of decentralized energy-generating systems. It was calculated that with a heavy emphasis on biogas installations, four million tons of kerosene could be saved annually. Thus, in 1973, the government launched an "All India Coordinated Project" to install 50,000 biogas plants in villages by 1978. About 36,000 plants were in operation by 1977.

When biogas technology came into favor with the state development planners, it was seen as contributing in several important ways to rural development. In addition to providing a valuable source of energy and fertilizer close to the sites of utilization, biogas generation and use would help conserve forests, prevent soil erosion, and improve India's balance of payments by reducing imports of oil and naptha.

A significant improvement in rural sanitation and public health was also seen as resulting from the fermentation of night soil (i.e., human feces) along with the cow dung and other vegetal materials in the biogas plants. With sufficiently complete digestion, the disease-causing bacteria and parasites infecting the night soil are killed off, producing an odorless humus that can then be safely applied to fields without endangering either farmers or consumers. Although a foul odor and health hazard may result if digestion is incomplete, the process is straightforward and not difficult to do properly. Biogas units could therefore help prevent the spread of parasitic and microbial diseases caused by fecal contamination. In addition, attaching toilets to biogas plants would save the expense of installing septic tanks.

Finally, it was believed that the extensive installation of biogas plants in Indian villages would have positive effects on the local economy, spreading basic technical skills, generating employment, saving capital that would otherwise have been spent on commercial energy and fertilizer, and promoting a spirit of self-reliance in the village for meeting basic energy needs.

One highly optimistic scenario went so far as to predict that biogas generation would play a key role in stimulating the village economy into a state of self-sustaining growth. According to this projection, the savings on fuel and fertilizer resulting from biogas use would free capital for the liquidation of debts and investment in irrigation, crop storage, and farm machinery. Such investments, along with the higher productivity of the land resulting from the use of biogas sludge as fertilizer, would increase incomes and augment cattle holdings. The cattle would in

turn produce more dung, supporting more biogas units, and so forth. Soon, sufficient gas would become available to run small scale industries and to generate electricity.

Unfortunately, this rosy scenario failed to take into account how the new technology would interact with the socioeconomic structure of Indian villages.

Constraints on Biogas Use

India's development has long been hampered by inequitable patterns of land, cattle, and income distribution, reinforced by the social hierarchy created by the caste system. Only 15 percent of India's village families own 75 percent of the arable land and purchase 68 percent of all machinery. The rural poor, whether landless or owning less than one hectare of land, belong predominantly to the lower castes and account for 60 percent of all village families and just over half of India's entire population.

A 1976 survey revealed that ownership of biogas technology is largely restricted to the upper third of the rural population, as defined both by income and social status. In the state of Haryana, which has the largest number of operating biogas units, the families that owned the plants had an average of 26 acres of land and 10 cattle, an annual income over $1,100, and were invariably literate. Nearly 40 percent of these people had subsidiary occupations in business or services. Why have only wealthy, literate farmers in India adopted biogas technology, in spite of its obvious benefits as a source of fuel and fertilizer?

The most obvious reason is cost. The initial outlay on even the smallest available biogas plants is about 3,000 rupees (approximately $335)--well beyond the means of all but the affluent farmers. The small farmer in India produces primarily for subsistence; whatever surplus he is able to market will generate only limited amounts of cash once or twice a year, and any spare cash must usually go to meet pressing agricultural or personal needs. Small farmers are generally unwilling to enter into new debts for a non-essential technology. And even if a small farmer could be motivated to go into debt to obtain a biogas plant, it would be very difficult for him to obtain commercial bank loans for this purpose, and interest rates would be high. Many banks insist that the borrower have at least five or six animals and a minimum of five acres of cultivated land.

A second problem is that many small, marginal, and landless peasants do not own enough land on which a plant could be sited near their home. Third, small-scale family units (with a capacity of 60 to 100 cubic feet of biogas per day) require at least three cattle to be economically vi-

able. Yet 70 to 80 percent of cattle owners in India have only one or two animals, and less than 5 percent have the four animals needed to run a small-scale plant efficiently. Fourth, there are cultural barriers to be overcome before a new technology can be incorporated into the age-old routines of village life. The illiteracy of poor farmers, and their psychological or religious inhibitions against the use of biogas made from waste matter for cooking food, provide additional obstacles to acceptance of biogas plants.

Finally, biogas technology requires considerable infrastructure in the village setting if it is to be successful. Experience has shown the futility of providing a new technology to a village without first training a cadre of people to operate, maintain, and repair it, as well as ensuring that there are local facilities for repairs and an adequate supply of spare parts. One example of this is the failed attempt to install biogas plants in some African villages lacking the necessary technical infrastructure. Outside technicians came into villages with the technology and installed and operated the plants without educating local farmers in the basic skills required to maintain them. Soon after the technicians left, the plants broke down or fell into disuse.

In sum, the poorer people in the rural sector simply do not have sufficient amounts of capital, input materials, land, or time to establish biogas plants effectively. One solution would be community-owned plants, like those in China where the largest numbers are found. But for a variety of reasons (not spelled out here) this would lead to conflicts of interest in villages, and seems impractical in India under existing conditions.

Technical Improvements Needed

One may conclude that the biogas technology is not appropriate to Indian rural society in that it would benefit chiefly the rich minority and might even disadvantage the poor. Indian rural social systems are unlikely to change very much in the foreseeable future; but technological change may be considered. What kinds of technical improvements are required to make biogas plants into a truly appropriate technology in the context of Indian village life?

First, there is a need to develop more efficient plant designs that can operate under a wide range of conditions. A second primary goal should be to reduce the capital costs of the technology by using cheap, locally available materials for its construction. For example, the KVIC design currently used in India is built primarily of steel and cement--both scarce and expensive materials. Moreover, the metal gas holder used has a rapid corrosion rate due to the acidic chemicals produced during the fermentation process. In China, biogas plants with no moving parts are made of masonry with a cement cap. Although this design uses

cheaper materials and has a much longer life than the Indian model, it requires extremely accurate bricklaying, necessitating skilled labor for its installation.

In India, a number of alternative materials are being investigated. Earthwork digesters lined with creosote or plastic may be a feasible alternative to cement tanks. Alternatives to the steel gas-holder might be made of ferro-cement, treated wood or plywood, discarded oil drums, or ceramic. Choice of materials should be limited, however, by the need to fabricate the plant with skills normally available in an Indian village.

A second area of research concerns increasing the chemical efficiency of the anaerobic fermentation process. Through the use of catalysts and the manipulation of conditions within the fermenter, it may be possible to accelerate fermentation to such an extent that the size of the tank could be considerably reduced, thereby cutting the costs of construction materials. Research is needed to determine the effects of manipulating acidity, viscosity, amount of agitation, and the choice and management of bacteria on the rate of methane generation. It is even conceivable that, using new gene-splicing techniques, scientists may be able to develop a strain of methanogenic bacteria that is far more efficient than existing strains. Such bacteriological research is currently under way at the Appropriate Technology Development Association in Lucknow, Uttar Pradesh.

Temperature control in the digester is another necessary step in the development of more efficient biogas-plant designs. Operation of plants at higher temperatures would increase biogas yield per pound of slurry and permit lower water-supply requirements. One approach has been to use some of the biogas produced by the plant to heat the fermenter to the optimal temperature. When the ambient temperature is 50 degrees F, only 10 percent of the gas is required to keep the temperature of the plant at 80 degrees F, yet this rise in temperature produces a 100 percent increase in gas yield. Another alternative is to incorporate a solar heating system into the biogas plant, although regulation of the temperature is difficult.

Attainment of optimal fermentation conditions would mean that much smaller fermenters could produce the same amount of biogas as the family-sized units now in use. The resulting reductions in the area of the masonry wall of the digester would result in substantial savings, and might enable the plants to run on the waste of a few goats and available night soil. Only at this point would the technology become attractive to owners of small and marginal farms, as well as to the landless poor.

Another area of research covers suitable materials--other than dung --for fermentation, particularly where the local economy has few live-

stock to produce dung. The establishment of solar-energy plantations may be considered for this purpose. In areas with ponds or lakes, floating water plants (particularly water hyacinths) proliferate without management and are a major aquatic pest. Attempts could be made to cultivate such plants for the purpose of fermenting them in biogas generators to produce methane and fertilizer, since the sludge obtained from digested water hyacinths is rich in potassium, phosphorous, and nitrogen. In hot, arid climates, herbacious perennials such as members of the amaranth family are obvious candidates for solar-energy plantations.

All of these research possibilities offer hope of making biogas technology truly appropriate to the socioeconomic realities of India, and to countries where conditions are similar. The question remains, however, of whether sufficient scientific expertise can be mobilized, both within India and in the developed countries, to do the necessary research and development on a vital but "non-glamorous" technology.

If and when biogas plants are developed that are appropriate to rural conditions, government officials will have to take steps to ensure that biogas extension programs reach into the more remote areas of the countryside, where the plants can do the most good, instead of being delivered to already developed areas. There is an understandable tendency to place new units in villages that are close to existing roads, towns, and power lines, due to the ease of access for construction and maintenance. At sites where commercial energy is already available, however, biogas power generation offers little or no cost advantage.

So far in India, there has not been a strong demand for biogas plants because of their technical shortcomings. Only when further research and development has produced a cheap, reliable and efficient digester that is within the means of all social classes will biogas be in a position to make a major contribution to equitable rural development in India.

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Biomass Gasification

Ernest Terrado

[The technique of gasification, in which wood or charcoal and certain crop residues are converted to a low Btu gas, called "producer gas," has been known for 150 years. This gas can substitute partially or wholly for liquid fuels in an internal combustion engine; gasifiers can also be used to provide heat directly in boilers, furnaces, and other heating applications. Over a million gasifier units, mainly used to power road vehicles, were in operation during World War II in Germany and Sweden. During the past decade, significant efforts have been made to revive and improve gasifier technology as part of the worldwide effort to develop better means of exploiting the energy potential of biomass. As a result, the technology is now becoming "commercial" in some industrial and a few developing countries.]

Biomass gasification is emerging as a realistic alternative to petroleum fuels in a variety of small and medium scale engine and heat applications. A good case can now be made for considering gasifiers in situations where wood and charcoal are readily available, and an adequate technical infrastructure exists. Gasifiers that produce fuels for vehicles and stationary engines are being sold in significant numbers in Brazil and the Philippines. Commercialization of gasifiers for direct-heat applications such as boilers and kilns is beginning to occur in Brazil, North America and elsewhere.

The scope for gasifiers will vary considerably among countries. In all cases, a reasonable local level of technical skills is essential for their safe and effective running. If there are difficulties

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looking after existing engines and boilers, the introduction of gasifiers will almost certainly exacerbate these problems. Apart from Brazil and the Philippines, the availability of gasifier hardware is one of the main restrictions on the use of the technology at present. Initial installations will have to rely on imported gasifiers, although local manufacture will probably be feasible in countries with a reasonably well developed manufacturing industry. In the long-term, the supply of biomass will be the main limitation on gasifier deployment. Tree planting should be regarded as an essential element in programs for the widespread promotion of gasifiers.

The Gasification Process

Gasification is a process in which solid fuels are broken down using heat to produce a combustible gas. A gasifier consists of a container into which fuel is fed along with a controlled quantity of air. Some of the fuel is allowed to burn, as in a normal stove or furnace, but the air supply is restricted so that combustion does not spread to the whole fuel load. By burning part of the fuel, enough heat is released to cause the chemical breakdown and gasification of the remainder.

The mixture of hot gases drawn from a gasifier is usually called producer gas. Typical gas composition from a wood gasifier is as follows (measured as a percentage of a dry gas):

Nitrogen	50-54%
Carbon Monoxide	20-22%
Hydrogen	12-15%
Carbon Dioxide	9-11%
Methane	2-3%

The heating value of producer gas is relatively low, typically ranging from 3.7 - 5.6 MJ/cu.m., or about 10-15% that of natural gas. In its raw form, it tends to be rather dirty, and may be contaminated with substantial quantities of tars and soot. It is essential that these are cleaned from the gas if it is to be used in engine applications. Producer gas is also extremely toxic, owing to its high carbon monoxide content--which is 4-5 times that found in normal car exhausts. Thus, leakage must be carefully guarded against.

Gasifier types. Most gasifiers fall into three broad categories, distinguished by the direction of the gas flow inside the gasifier. Updraught gasifiers are the simplest. They tend to produce a dirty gas, however, and their use is largely restricted to direct-heat applications. Down-draught gasifiers are the most common, and are generally the first choice for engine applications. When working properly, they produce a relatively clean gas since much of the tars produced are broken down inside the gasifier. Cross-draught designs have the advantage of a more rapid response to load changes, but they need high-quality charcoal as fuel.

Large-scale gasifiers also use a variety of other more sophisticated approaches, such as fluidized-bed and dual-chamber techniques. These are more complex and more expensive but give greater control over the gasification process.

The size of shaft-power gasifiers is usually given as the peak output, in kilowatts (kw), of the engine to which it is connected. Currently available commercial shaft-power gasifiers range in size from 7.5 kw to about 480 kw. The size of direct-heat gasifiers is generally specified as the thermal value of the gas they produce at peak output. Most of the present systems are in the range 0.25 - 25 GJ/hour.

Gasifier Fuels

At present, wood and charcoal are the only biomass fuels which can be confidently recommended for use in gasifiers. Charcoal is the simpler to use because it produces a cleaner gas. This cuts down gas-cleaning requirements and reduces hardware costs. Charcoal gasifiers are also more flexible in their response to load changes. The main disadvantages of charcoal are its higher cost and the energy losses in its manufacture. Coconut shells and maize cobs are among the most promising alternatives to wood and charcoal, but their use should still be regarded as experimental. Rice husks are widely available as a waste product, but cannot be used in any presently existing commercial gasifiers. Loose sawdust is not a good fuel for engine gasifiers.

Both the size and moisture content of fuels must be carefully controlled if reliable operation is to be achieved. Requirements are particularly strict in the case of shaft-power gasifiers, where a very clean gas is essential for trouble-free engine running. In countries with a scarcity of wood resources, the widespread use of gasifiers could seriously aggravate existing fuel supply problems.

Engine Power Applications

Rural industries currently using diesel engines are a primary candidate for the introduction of gasifiers--both for shaft-power and in-plant electricity generation. The main requirements are that the power demand should be fairly steady and that a suitable supply of fuel is available. Two applications in which gasifiers appear suitable in principle are sawmills and crop processing activities, such as maize milling. In both cases, low value biomass residues (hogged or chipped woodwastes, corn cobs) are produced as part of the industrial process, thereby providing a potential gasifier feedstock. Prototype testing will be required, however, for any fuel other than wood or charcoal.

Rural electrification. Diesel-powered electricity generators are used widely in rural areas of many developing countries. Where wood re-

sources are abundant, the opportunity exists for running diesel generator sets on producer gas. Plantation-grown wood can also provide the fuel for gasifier-powered electrification schemes in regions where the necessary land and infrastructure exist.

Irrigation. Gasifiers can be used to run diesel or gasoline-driven irrigation pumps in areas where cheap wood or charcoal are available. The economics are most favorable in cases where the irrigation season is long. With plantation-grown wood, approximately 6 hectares of plantation would be required, as a rough rule-of-thumb, for every 100 hectares irrigated. Despite the large number of potential applications, however, there are no commercial gasifier systems available at present suitable for pumps smaller than about 7.5kw.

Vehicles. Where liquid fuels are expensive and wood resources are plentiful, an economic case can be made for converting vehicles to run on producer gas. Practical disadvantages that must be taken into account include reduced convenience, performance, and payload capacity.

Direct-heat applications. The main direct-heat application for gasifiers is in industries where fuel oil is currently being used to generate process steam, or to run furnaces, driers or kilns. Examples include food processing, brewing, glass and brick making, ceramics, and greenhouses. Fuel availability and cost will be the most important limitation on gasifier use in the majority of locations.

Economics of Engine Gasifiers

Capital costs are the dominant factor affecting the economics of gasifiers that produce an engine fuel, since there is a ten-fold variation in the cost of the gasifier systems currently on the market. Other important variables are the cost of the fuel being replaced, the annual operating period, and the lifetime of the equipment. Where engine gasifiers can be supplied at prices below $200/kw (not including the engine), as is now the case in Brazil and the Philippines, gasifier fueled engines will be competitive with conventional diesel or gasoline engines in many applications. Even taking into account the high operating and maintenance costs of a gasifier system, reductions of 10-40% in the total cost of producing shaft power will often be possible through fitting a gasifier, with payback periods on the gasifier equipment of between six months and two years.

With gasifiers costing more than $400/KW, however, as is the case with systems imported from Europe or North America, there are relatively few circumstances where the economics are favorable. High liquid fuel costs (above 60 cents/liter), and long annual operating periods, would be needed to justify the installation of gasifiers in this price range. In stationary applications, even low-cost gasifiers are unlikely to be

competitive where electricity from a central grid is obtainable at a cost of less than 10 cents/kwh. This restricts their use to rural areas where grid electricity is either expensive or unavailable.

Economics of Dirct-Heat Gasifiers

With the gasifier systems currently being sold in Brazil, New Zealand and the United States, savings in energy costs of 25-60% are possible by retrofitting oil-fired heating equipment with direct-heat gasifiers, with payback periods of less than two years. The primary requirement for cost-effectiveness is that the price of fuel oil (or natural gas) being replaced is in excess of $175/tonne ($4/GJ). Savings will be greatest where annual operating periods are long, and systems are run at close to their maximum output. While gasifier economics are obviously favored by low biomass costs, cheap biomass is not always essential. Plantation-grown wood costing up to $40/tonne (air dry) can be an economically viable fuel for both shaft-power and direct-heat gasifiers. Where liquid fuel prices are exceptionally high, correspondingly higher prices for wood can be tolerated.

Some Technical Considerations

In principle, any internal combustion engine can be converted to run on producer gas. The precise modifications depend on the engine type, its intended use, and the degree of control required on its running. Usually they are within the scope of a reasonably well-equipped engine repair workshop. In practice, however, there may be considerable problems in the conversion of some makes of engine. Most gasifier manufacturers recommend that their equipment should be used with specific engine types.

Gasoline engines may be converted to run entirely on producer gas. Diesel engines, in contrast, require a small diesel injection during each engine cycle to ensure that ignition occurs, referred to as 'dual-fuel operation'. The maximum diesel fuel replacement is about 90%, but savings of 50-80% are more typical in practice because extra diesel fuel is generally used to take up sudden load increases. A reduction in maximum engine output occurs when using producer gas to run engines. With diesel engines the power loss is usually about 20-30%, but with gasoline engines it may be as much as 40-50%. Gasifier-powered vehicles tend to be somewhat sluggish, and have to rely on greater use of their low gears.

Engine lifetime when using producer gas depends on the quality of the gas reaching the engine. Careful operation and maintenance, careful choice of fuel, and an efficient gas-cleaning system are all essential to ensure a clean gas. Without these precautions, engine lifetime is likely to be severely impaired.

Many oil and gas-fired heating appliances can be converted to producer gas by simply removing the existing burner and replacing it with a producer gas burner. Gasifiers will not always be able to match the performance requirements of conventional heating systems, however. Most currently existing direct-heat gasifiers range in output from 0.25 to 25 GJ/hour.

In most cases, direct-heat gasifiers are economically best suited in retrofit applications, as this allows the cost advantages of switching to a biomass fuel to be obtained without replacing the entire heating system. When a furnace or boiler system is being installed from scratch, the possibility of burning wood or biomass directly must also be considered. This technology is simpler and better established, and systems are able to deal with a wider range of fuel types than most gasifiers. Conventional woodburning equipment may also be cheaper, particularly with large-scale systems (above about 20 GJ/hour). In new installations, gasifiers are likely to have a clear advantage only in specialist applications, such as in the glass or ceramics industry where a controllable or clean-burning flame is important, or where anti-pollution regulations require a particularly rigid control of flue-gas emissions.

Safety

The question of safety needs to be taken very seriously. Producer gas contains substantial quantities of carbon monoxide, a clear and odorless gas which even in small quantities can bring about rapid death. Gasifiers should only be used in places with good ventilation, and regular checks must be made to detect possible gas leaks. Good operating procedures are also essential. With care and proper precautions, gasifiers can be made to work to an adequate level of safety, but this requires full recognition of the hazards involved. Producer gas should never be considered as a village cooking fuel.

[Extracted from a brief synopsis of the current status of gasifier technology for proposed guidelines, World Bank, January 1983.]

Note: The views expressed here are those of the author and not necessarily those of the World Bank.

This text was based on: G. Foley and G. Barnard, "Biomass Gasification in Developing Countries: Final Report to the World Bank," Earthscan, December, 1982.

Wind Power: Chimerical Hope or Practical Possibility?

Jonathan P. Hodgkin

[An old technology, pumping water by wind power, today is attracting much attention as an alternative energy source in developing countries. Promising experiments are under way, but more technical and economic research, as well as education and training, are needed.]

There is often a perception that windmills are not in fact a viable means of tapping an alternative energy source (see cartoon on the next page). It should be pointed out to those skeptics that the use of the wind as a source of energy goes back thousands of years. Sailing ships made possible the growth of many empires, from the Phoenician to the British, while a significant part of the land area of the Netherlands owes its usefulness to the windmills that pumped it dry.

The wind that performed these tasks still blows. It has been estimated that wind energy available around the world is 40,000 quads per year. This is equivalent to 11.7×10^{15} kilowatt-hours--or over 100 times the present global energy demand. Of course, not all of this energy is readily available. Much of the wind blows over the world's oceans where it is difficult to capture. But a significant portion is available over land masses, although it is not evenly distributed, so that wind energy is not an economically viable alternative in some parts of the world.

In many countries, however, the wind is not only a readily usable energy source but has been in use for

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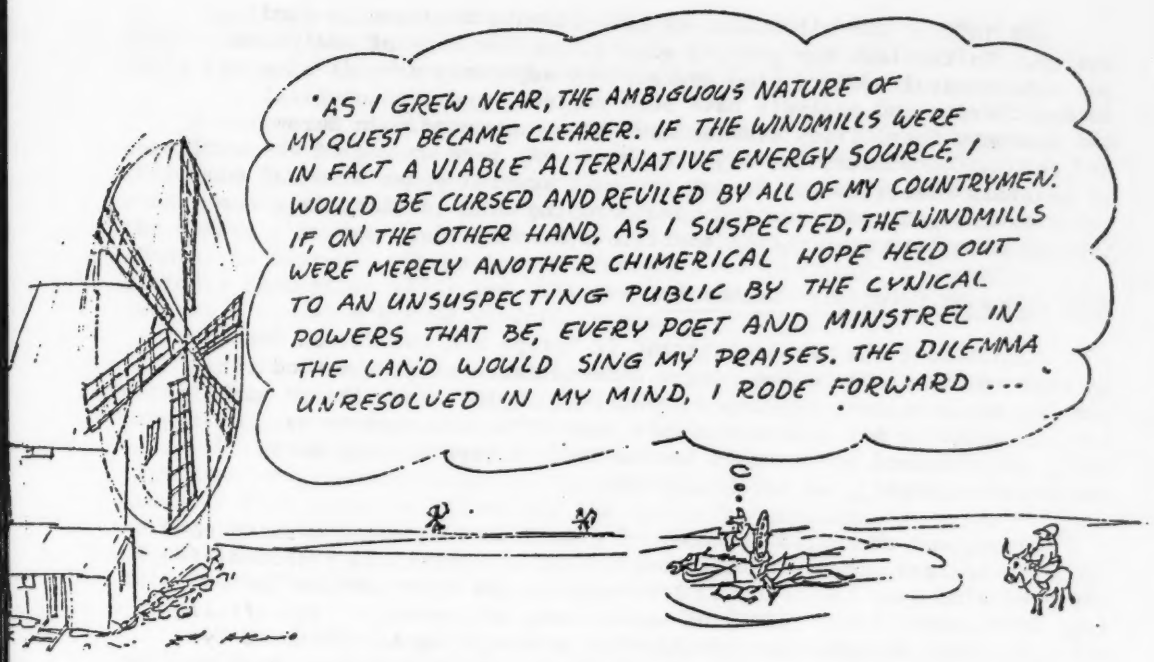
"AS I GREW NEAR, THE AMBIGUOUS NATURE OF MY QUEST BECAME CLEARER. IF THE WINDMILLS WERE IN FACT A VIABLE ALTERNATIVE ENERGY SOURCE, I WOULD BE CURSED AND REVILED BY ALL OF MY COUNTRYMEN. IF, ON THE OTHER HAND, AS I SUSPECTED, THE WINDMILLS WERE MERELY ANOTHER CHIMERICAL HOPE HELD OUT TO AN UNSUSPECTING PUBLIC BY THE CYNICAL POWERS THAT BE, EVERY POET AND MINSTREL IN THE LAND WOULD SING MY PRAISES. THE DILEMMA UNRESOLVED IN MY MIND, I RODE FORWARD ..."

Cartoon of Don Quixote attacking a windmill (from New Yorker magazine of April 11, 1983; reprinted with permission of publisher).

many years. Vertical axis grain-grinding windmills were used in Persia as early as 200 B.C. In China, wind pumps have been used for centuries to raise brine to drying beds in order to extract salt. By the 14th century, the Dutch had become leaders in wind energy use by developing wind pumps to drain the lowland areas of Holland.

The technology that led to today's water-pumping windmills was developed and refined on the farm and ranch lands of the American West in the late 19th century and the first decades of the 20th century. During this time there were over 100 manufacturers of what became known as American farm windmills. Today only three of these companies survive: Aermotor, Dempster and Heller-Aller (manufacturer of Baker). A decline in the use of windmills in the United States was caused by rural electrification during the 1930s and 1940s. However, in other parts of the world, notably Australia, South America, and southern Africa, these windmills were introduced and have flourished.

The jolt of the oil crisis of 1973 reawoke interest in wind energy. In the last ten years a significant new body of analytical and experimental work on wind systems has appeared; methods of wind data-gathering and analysis have been refined; and technological and economic feasibility studies have been completed. In Europe and the United States, the major emphasis has been on use of the wind to generate electricity. During the past several years over 150 countries have begun marketing and manufacturing wind turbines in sizes ranging from less than one kilowatt to 2.5 megawatts.

Wind Pumps in Developing Countries

Paralleling the recent interest in Europe and the United States in wind turbines, there has been a renewed interest in the wind for pumping water in less developed countries. Using windmills to pump potable water is not only one of the most efficient ways to use the wind, but also one of the most cost-effective ways to pump water whether for drinking or for irrigation.

Throughout the world a number of organizations, often working cooperatively, are addressing the theoretical and practical problems of improved wind pump technology. For example, the Intermediate Technology Development Group (ITDG) of London and, subsequently, its affiliate I.T. Power designed a windmill that is now being manufactured by Bob Harries Engineering Ltd. in Thika, Kenya. This project, which began in 1975, has resulted in a production line of 12-foot, 16-foot, 20-foot, and 24-foot diameter windmills that are now being used in Kenya and other African countries for moderate to deep well pumping applications. I.T. Power is also working with collaborators in Pakistan and Botswana to manufacture wind pumps.

In Cape Verde, with the assistance of the Netherlands-based Steering Committee on Wind Energy in Developing Countries (SWD), the government is actively promoting the use of wind energy. The goal is to use wind to pump 75 percent of all drinking and irrigation water on the main island of Santiago and to have 75 percent of those wind pumps be of improved design and local manufacture. The remainder will be imported windmills or mills of indigenous designs that have been in use for many years. SWD is also assisting wind pump manufacturing programs in Tanzania and Sri Lanka.

Sailcloth wind pump designs have a long history in Thailand. With support from Volunteers in Technical Assistance (VITA) and funding through USAID, a six-meter (19.7 ft.) diameter wind pump has been developed for irrigation purposes, thus allowing a crop planting during the dry season. This new design, now in the first phase of being manufactured and marketed by Thai entrepreneurs, utilizes laminated wooden blades and a traditional chain and washer pump. This wind pump

is a significant improvement over sail wing designs and is capable of pumping 60 m^3 per hour (15,850 gal.) at a pumping head of 1.5 m (5 ft.). There are now 7 of these windmills installed in Thailand.

A number of organizations in developing countries are working on specific technical problems. The Rural Industries Innovation Centre (RIIC) in Botswana has been exploring the use of windmills to drive rotary mono pumps. Work on Savonius rotor windmills has been done at the Centre d'Etudes et de Recherches sur les Energies Renouvelables (CERER) in Senegal. In Cuernavaca, Mexico, the Instituto d'Investigaciones Electricas (IIE) and VITA are collaborating on the development of a variable stroke windmill system.

Wind resource assessments are also being completed to aid in determining the economic feasibility of wind energy. This work is progressing in many countries through research groups and universities. Latin American countries have banded together to form the Organizacion Latinoamericana de Energia (OLADE) to focus on regional issues. This group is collecting and analyzing wind data in order to develop a wind energy density map for Central and South America. It publishes reports, sponsors conferences, and plays a coordinating role in the national programs of its members.

Attention is also being given to education and information dissemination in many countries. The Asian Institute of Technology (AIT) in Thailand, the Tata Energy Research Institute (TERI) in India, and the Science Council of the Commonwealth Secretariat based in the United Kingdom are examples of organizations working on national and regional information exchange and education. TERI publishes "Wind Pump News" on wind topics, while the Commonwealth Secretariat has sponsored workshops on low-cost water pumping and wind data collection and analysis.

Need for Research and Training

The decision to use wind pumps requires a thorough knowledge of wind regimes in the specific areas where windmills are to be employed. The nature of the wind is such that while large geographical surveys are useful, the wind at specific sites may vary considerably. An expanded body of wind data collection in areas of highest likelihood of use is needed.

Conventional fixed-stroke wind pumps operate at an overall efficiency of less than 10 percent. It has been shown that the use of a variable stroke device that alters the pump stroke length as a function of wind speed can significantly improve wind pump performance. VITA is actively working to develop such a device that is both reliable and cheap. However, detailed design work is just under way.

An economic model to evaluate wind energy potential on a site-to-site basis is necessary in order that a reasonable comparison with solar pumps or conventional diesel pumps can be made. Wind energy is a good resource in many areas but responsible decisions require that alternatives be considered also.

Finally, education and training of users and potential users of wind pumps are necessary. Though windmills are not complicated machines, many are in disrepair. End users must have a feel for wind power and know how a wind pump works. Training of local personnel for periodic maintenance and simple repairs is required. A reliable organizational network is also necessary to enable end users to obtain spare parts and repair assistance when needed. Most problems with wind machines occur in situations where these complementary factors are not present.

Windmills are, in fact, a viable mechanism for using an alternative energy source for the future. So vast are worldwide resources that if even a small percentage of the available wind energy is ultimately used, it can make a big difference. Unlike oil- and coal-fueled processes, once the capital costs of harnessing wind energy are satisfied, the only ongoing costs are maintenance and repair. With work and planning, wind can play a significant role in meeting the future energy needs of both the developing and developed countries.

[Adapted from an unpublished paper prepared for Volunteers in Technical Assistance (VITA), 1815 N. Lynn St., Arlington, Va. 22209, U.S.A. June 1983.]

Learning from China's Experience

Robert P. Taylor

[China's rural energy programs have several unusual features which should be of interest to other developing countries. Given the country's size and weakness in transportation capabilities, local authorities were authorized and encouraged to mobilize local resources, usually on a small scale. The methods used and some of the technologies are discussed.]

Since the beginning of the Cultural Revolution, China has followed a balanced approach to rural energy development. Under the policy of "walking on two legs," China has emphasized both large centralized undertakings employing advanced technology, and small decentralized undertakings employing intermediate technology. Energy development under the centralized "leg" has played the most important role in providing modern energy inputs for agriculture, while decentralized energy programs have played the most important role in development aimed at easing rural household fuel problems. It is China's experience in the development of decentralized rural energy systems which seems to present the most valuable lessons for other developing countries.

Of course China's development programs in forestry, small coal mines, small hydroelectric plants, and biogas all reflect the country's particular geography, climate, resource base, and traditions. Other developing countries with different characteristics may not be able to promote similar programs due to absence of comparable resources, or they may have difficulty adapting certain aspects of the Chinese programs in a different setting.

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In biogas development, for instance, the tradition of collecting and composting human and farm wastes for fertilizer in China has been a major factor in the popularization of the technology. In many other developing countries, however, fertilizer from human and animal wastes may play a less important role in agriculture, and farmers may be unfamiliar with, or even opposed to, the collection of these wastes, especially human wastes. In addition, the availability of suitable resources may also present a more serious problem in some countries than in China. In India, for example, it is commonly asserted that the manure from three or four cows is required for the operation of family-sized biogas digesters, but only 10 to 15 percent of the rural families in India possess this number of cows. In China, by contrast, not only are human wastes and crop by-products normally used but, perhaps more important, most rural households in Sichuan and many other parts of China privately raise pigs. The manure produced by household pigs is easily collected, as the pigs are penned in. In addition, pig manure is a far better raw material than cow manure for producing biogas. At low temperature ranges, about twice as much biogas can be produced from 1 kilogram of pig manure than is produced in India from 1 kilogram of cow manure. Despite such differences, the experience that the Chinese have gained over the years can clearly be valuable to other countries.

Lessons Concerning China's Approach to Decentralized Rural Energy Development During the 1970s

The policies and attitudes toward decentralized rural energy development adopted by the Chinese during the 1970s have been a fundamental part of both the success that China has achieved and the problems that China has encountered. The methods adopted during the 1970s proved remarkably effective for the rapid popularization of decentralized energy technologies on a mass scale. However, the approach of the 1970s also caused some important problems, including low technical levels, insufficient attention to quality, cases of local mismanagement, and a lack of proper coordination in some instances. A good understanding of the advantages and disadvantages of the Chinese approach should be useful to those interested in pursuing decentralized rural energy development.

It should be recognized, however, that a broad commitment by the central government and communist party authorities to rural development and the existence of a well developed rural organizational framework have both been critical in implementation of the Chinese approach. China's commitment to rural development has been important in terms of both the provision of active support for individual programs and China's ability to realize the advantages of the integration of decentralized energy programs with broader rural development efforts. China's commune system has provided an effective framework for development efforts which are locally based: communes, brigades, and teams

have been given the authority to mobilize and allocate funds and labor for projects of varying size. Thus, within a strongly hierarchichal system, China's communes, and to some extent the brigades and teams of which they are composed, generally have a high degree of autonomy in pursuing specific local projects in response to their own needs and conditions. At the same time, however, strong linkages between the communes and country governments, various government departments, and special technical organizations provide guidance and direction as well as technical assistance for local efforts.

There is no fundamental reason to think that important aspects of China's approach to decentralized rural energy development can only be applied to other developing countries after a political revolution such as China's, or through the establishment of a Chinese-type commune system. However, application of many aspects may be ineffective without a firm government commitment to (1) rural development aimed at meeting the needs of the rural poor, and (2) the development or strengthening of locally based rural organizations that have adequate linkages to regional and central governments and departments, and the authority to mobilize local and/or central resources for fairly comprehensive local development programs.

Emphasis on low-cost technology, and the use of local materials and labor-intensive methods. Policymakers in most developing countries have recognized the importance of developing low-cost, labor-intensive systems which use local materials, but in China these priorities have been pursued with a degree of intensity that rarely is found elsewhere. In turn, strict attention to low costs, simplicity of design, and a reliance on local materials and labor in the development of decentralized rural energy systems have been major factors in China's ability to diffuse the relevant technology on such a wide scale. This approach has sometimes resulted in lower quality, poorer technical performance, and lower efficiency than one might desire. However, it also has distinct advantages. If capital costs can be lowered to the point at which local organizations can afford them, development can proceed rapidly, local funds can be relied on for development, and heavy state investments or subsidies, which place a burden on the state, can be avoided. In addition, when technology is relatively simple, when local materials are used, and when local labor is employed in development, technology is diffused more easily because residents can pursue projects largely by themselves without awaiting the delivery of scarce materials or equipment.

The Chinese have selected the basic water-pressure biogas digester for popularization among China's rural households. When compared with other common designs, the technical performance of the water-pressure digester may be inferior, but it is far cheaper and can be built by local people with local materials. The Chinese have been able to construct some 7 million digesters in less than a decade. In China's small coal

mines, heavy reliance on human and animal labor, lack of sophisticated equipment, and disregard for the preparation of the coal produced may have caused production to be less efficient, and quality levels lower than might be desired. However, because capital costs have been held at a minimum, a large number of local units have been able to open and operate small mines, and these have been established rapidly with local resources. Although the quality of coal may be low, it can meet a variety of local needs. Similarly, in China's small hydro program local units have often substituted local materials or locally made machinery for higher-quality materials or machinery, reducing technical performance and efficiency, but also capital costs. These types of substitutions have put small hydro development within the grasp of many local units which would not have been able to afford higher-quality plants, at least initially.

In some areas of rural industrial development, emphasis on the use of local materials and a high degree of self-sufficiency has led to a degree of waste and neglect of quality and efficiency that is currently judged unacceptable by China's leaders. Although such problems are less apparent in the decentralized energy programs, the current leadership is pushing for greater attention to quality and efficiency than in the past. Current attitudes display a recognition of the tradeoffs involved.

Emphasis on local management, control, and participation. In keeping with the doctrine of self-reliance, local units in China have usually played the major role in the planning, management, and control of specific decentralized rural energy projects. But China's central or regional governments and the Communist party have also played important parts in the promotion of decentralized rural energy development, ranging from the exertion of strong pressures from the top on local units to pursue specific programs to the provision of information or guidance concerning the possible programs that local units might wish to pursue.

One of the major advantages of the delegation of much of the initiative and planning, control, and management responsibilities to local units is that strict attention can be given to local conditions. In a country as large as China, local needs and resources vary dramatically, and attention to variations is critical in all the decentralized energy programs that China has developed. Residents have the best perception of a given local setting and local needs. If a great deal of flexibility is maintained in promoting programs and local people play a major role in the development process, attention to variations in local conditions can be more effectively realized than might otherwise be the case.

An additional advantage to heavy local involvement in the development process is that it helps develop local pride in projects and a

feeling of self-confidence. For example, when a commune pursues electrification by building its own small hydroelectric plant, commune members can obtain a great deal of satisfaction from the knowledge that the power plant is distinctly theirs and that they have managed to electrify their homes and fields through their own efforts.

While Chinese experience points to the advantages of emphasizing local management, control, and participation in development, Chinese experience also shows that problems can result when this approach is pushed too far, and planning and coordination at higher levels is neglected. Local development may require the provision of certain equipment or materials from outside a given locality, and in the Chinese system supply must be arranged at higher levels. In the biogas and small hydro programs, a lack of attention to the problem of supply of necessary equipment and materials has slowed down development in some cases. When central or regional planning is weak, development efforts may not be properly focused on areas where opportunities are most advantageous. This has been a major problem in the biogas program. Finally, when local people take on most of the responsibility for planning and managing local projects, they may make mistakes if they have not received adequate training.

Emphasis on local innovation, local involvement in the technology diffusion process, and the fusion of training, extension, and adaptive research with innovation. In China's decentralized rural energy programs, local people have not only played roles in planning and managing projects, they have also been involved in the technology diffusion process and the innovation associated with the adaptation of technology to local conditions. In contrast to other methods of technology diffusion, in which outside experts play the leading role in bringing new technology to an area and adapting it to local conditions, the Chinese have emphasized the training of local people to pursue such development themselves. Local people often act as extension agents, and they have been encouraged to "learn by doing." They conduct scientific experiments and employ new ideas and innovations in an effort to gear the new technology to local needs and resources. By having these experiences, residents develop technical abilities and knowledge which can be useful to the local community. A local contingent of low-level technicians is established, who in turn can train others and play a key role in operation, management, maintenance of equipment, and the conducting of scientific experiments.

Moreover, by encouraging local innovation, a wide variety of designs and techniques have been developed in China. Such innovation has been particularly evident in the construction of biogas and small hydro plants with local materials. The creativity of local people has been relied on heavily in the development of different designs that are least expensive for given local settings.

China's government has made major efforts to help local units adapt decentralized energy technologies. For example, one of the important functions of state forestry, water conservancy, or electric power departments and research organizations is to train local people and provide on-the-spot advice for those experiencing difficulties. In China's biogas program, special biogas offices have been set up in a number of regions to provide similar services. The state has also helped organize exchange visits, so that others can learn from the experiences of localities that are relatively advanced in the popularization of a given technology. Regional and national conferences have been organized so that people can exchange experiences. A wide variety of technical manuals have been published and distributed by the state. Written in a simple and straightforward style, they present useful technical data, and give detailed advice concerning different methods, designs, construction techniques, and so forth. Without such government assistance, success would not have been possible. Even so, a great deal of work remains to be done to improve quality.

China's leadership has recently emphasized the need to move toward greater standardization in technology in the small hydro and biogas programs as a means to improve quality levels. As past experience shows, the encouragement of local innovation and the development of different local designs can help ensure that technology is geared toward particular local conditions. Standardization of technology, on the other hand, can help ensure that certain technical standards are met, prevent a multiplicity of efforts resulting in waste, and help guard against serious mistakes in design and construction. While innovation and the development of different local designs have clearly been important factors in China's success in biogas and small hydro development, Chinese leaders feel that a movement toward standardization of technology could benefit the programs at this point.

Emphasis on multipurpose programs that are well integrated with the local economy. Decentralized energy development has been but one part of a comprehensive rural development program aimed at meeting the basic human needs of the rural population and the achievement of agricultural modernization and rural industrialization. Local leaders have the responsibility for a variety of different programs, leading toward a more holistic approach to development than might otherwise be the case. The energy provided by decentralized systems has been used in a variety of sectors in the rural economy, including rural industry, rural households, and agriculture. Especially important, projects to provide fuelwood through afforestation, biogas fuel, or electricity from small hydro plants have usually been developed as parts of multipurpose programs.

In local forestry development, for example, provisions for fuelwood supply are often an integral part of such multipurpose programs as "four around" planting (planting along roads, along rivers and

canals, around homes, and around villages), the development of larger collective forests for protective purposes or the production of timber, fruit, nuts, or oils, or systems for closing mountainous areas to allow natural regeneration. China's small hydro plants have usually been developed as just one aspect of multipurpose water management schemes, which may be designed to improve flood control, water storage capabilities, irrigation and drainage, navigation, and fishery industries, in addition to providing electricity. In developing biogas plants, attention has been given to both the provision of a new fuel source and the improvement of rural techniques in the management of fertilizer and organic residues.

Effective management of multipurpose systems, however, can be tricky. Systems must be planned and managed so that one function is not overstressed to the detriment of another, and this can prove difficult. Available information indicates that the Chinese have experienced problems concerning balanced management in both the biogas program and multipurpose forestry projects.

In the biogas program, many local units have had difficulty balancing the use of digester slurry and sludge for fertilizer and the production of biogas fuel. Problems may be compounded by the fact that gas production involves the interests of individual households, while the use of digester slurry and sludge for fertilizer involves primarily the interests of the collective. Some units have focused their attention on the use of fermentation materials for fertilizer, and neglected the fuel needs of families, while other units have only paid attention to fuel production, resulting in problems concerning the supply of fertilizer. Biogas digesters can be used in a way in which both fertilizer and fuel needs are met, but careful planning and management are critical. This is one reason why the Chinese government has emphasized the need to establish special groups at the team level to oversee the preparation of digester inputs and to plan and manage the loading and unloading of digesters.

In many local forestry development schemes, provisions have been made for the supply of fuelwood from forests which are designed primarily for other purposes. In theory, a certain amount of fuelwood can be harvested from local forests in a way in which those forests are not harmed, or may even benefit. In practice, however, it is very easy to step over the vague line which distinguishes multiple use from forest abuse. For example, a brigade may periodically allow its members or a special team to enter a local shelterbelt to pick up dead wood or prune and thin trees, and use the wood for fuel. Supplementary fuel can thus be provided without harm to the shelterbelt; indeed, the shelterbelt may be improved with effective pruning and thining. However, the opportunity to enter the shelterbelt may be abused, and the trees severely harmed.

Chronic problems in forest abuse seem to have prompted a movement away from attempts to supply fuelwood from forests designed primarily for other purposes. At present, greater stress appears to have been placed on the establishment of collective or individual forest plots specifically designed to produce fuelwood.

Some Lessons Concerning the Specific Technologies and Methods Employed in Individual Programs

Of all of China's decentralized rural energy programs, the biogas program has probably attracted the most attention in other developing countries, with respect to both the technology that is employed and the methods used for popularization of this technology. The low cost and simplicity of the basic Chinese water-pressure digester design have attracted considerable interest in other countries. Responding to this interest, the Chinese have exhibited a willingness to help other developing countries learn about the technology. Study tours have been organized, technical data has been exchanged, and one-month training seminars have been held for persons from other developing countries in Chengdu, Sichuan, in 1979 and 1980 in cooperation with the United Nations. Recently, China has also agreed to the establishment of a biogas development, research, and training center in China, under the auspices of the United Nations Development Program (UNDP). And in fact several developing countries have decided to initiate programs for the construction of Chinese-style water-pressure digesters.

Careful consideration of Chinese methods for the diffusion of biogas technology would also be particularly worthwhile for other developing countries interested in biogas development. In areas such as Sichuan, where an emphasis on local involvement and innovation in biogas development has been backed up by a complete top-to-bottom development and management infrastructure, biogas development has been both rapid and effective. In Sichuan, a good mixture of local involvement and state assistance appears to have been achieved. Other parts of China have been encouraged to learn from Sichuan's experience, and other countries could benefit from investigation of biogas development methods in Sichuan as well.

Two important aspects of China's experience with small-scale hydroelectric power plants that other developing countries may wish to consider are the integration of small hydro plants in comprehensive water management schemes, and the specific technology employed in China's small hydro plants.

As mentioned previously, small hydro plants in China are only one part of integrated water management schemes, in which local needs concerning water storage, irrigation, flood control, navigation, and fishing are carefully considered in addition to local electricity needs. In fact, in creating water management schemes, electricity generation may be low on the list of priorities and considered basically as a

side benefit. Careful attention to the maximization of benefits and multipurpose functions of hydraulic structures such as dams, reservoirs, and canals has been an important element in China's success in small hydro development. Other developing countries considering small hydro programs would certainly benefit from a study of the Chinese approach and the wide variety of innovative local water management schemes that have resulted. The Philippines signed three agreements in 1980 to obtain small-scale hydroelectric technology from China.

In October 1980, the UN Industrial Development Organization sponsored an international small hydropower conference in Hangzhou, in which technical experts from more than twenty countries participated. Even more important, the Chinese government and the United Nations Development Program recently reached an agreement to establish an international small hydro training and research center in China. The center will train technicians from developing countries, provide technical assistance for small hydro projects in various nations, and organize international research and technical exchanges.

One aspect of decentralized rural energy development in China that clearly warrants further investigation is China's development of various methods to provide fuelwood through afforestation. (See Development Digest October 1979, p. 31.) Mass participation has been a crucial element in the Chinese forestry program, and the establishment of a well developed hierarchy of state forestry organizations that are closely linked to local collective units has been influential in making mass participation a working reality. Through the organization of a variety of educational, training, and decentralized research activities, China's state forestry organizations have provided much of the necessary support for local forestry programs.

The Chinese have expressed a willingness to share many aspects of their experience in decentralized rural energy development with other countries, and it is hoped that understanding of the Chinese experience will continue to grow. It will be interesting and instructive to see how China's decentralized energy programs develop in the coming years. During the 1980s, China's approach to decentralized energy development will probably be considerably different from what it was during the 1970s. During the 1970s the desire to initiate development was perhaps the chief concern. Given the recent reorientation of general policies toward rural economic development and the steady advancement of China's capabilities, a new stage of development may occur in the 1980s involving greater emphasis on technical performance, quality, and efficiency. In all events, future developments in China will certainly be worth our attention.

[Extracted from Chapter 9 of Rural Energy Development in China, pp. 223-43. Copyright© 1981 by Resources for the Future, Washington, D.C.]

Small-Scale Renewable Energy: A Questioning View

Gerald Foley

[Failure of renewable energy sources in developing countries to be used often results more from lack of effective demand than from limits on supply; greater developmental benefits may be obtained from familiar actions than from technological novelties.]

An economic transition from subsistence to market sales is the aim of development strategies everywhere. When it occurs many of the problems of fuel supply become resolvable. With rising rural incomes, the depletion of free-good wood resources opens the way to commercial substitutes. A typical transitional sequence is, first, the commercialization of firewood; next a more extensive use of charcoal; then the employment of kerosene, benzine, bottled gas, or even coal. When economic conditions improve sufficiently the use of electricity becomes universal.

In the newly industrializing countries this transition is well under way. In the industrial countries it occurred much earlier. Abraham Darby is celebrated for making the industrial revolution possible with his discovery in 1709 of how to make iron using coal instead of charcoal. It is less well recognized that in the century and a half prior to that, England had undergone a transition from free-good fuelwood to the use of coal as a domestic fuel.

It is tempting to see contemporary parallels. With the commercialization of fuel comes a "price" on the time of those who collect it. It makes economic

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sense to invest in means of improving the efficiency of use and in changing to more convenient or cheaper substitutes. When fuelwood has a commercial value there is a possibility that someone will be prepared to invest in planting trees.

Another feature of the economic transition from subsistence is a widening of the area of economic activity and a much greater range of end-uses for energy. Mechanized agriculture, water pumping, food processing, small manufacturing and workshop enterprises, services, and the provision of social amenities all use energy in different ways. In the European economic transition out of the Middle Ages, this was the time of windmills, waterwheels, tidal mills, and eventually, sweeping all before it, coal. It is within this modern transitional sector that the greatest number of possibilities for the use of renewable energy technologies occurs. Identifying exactly where initiatives should be made, however, requires care. There is a superficial attraction in enumerating the tasks that might be powered by renewables and then endeavoring to supply the hardware to accomplish this. All over the developing world, however, can be found the derelict remnants of projects based upon such an oversimplified analysis.

Technology cannot be abstracted from the priorities and constraints of the society it is supposed to serve. Often a lack of energy occurs because of the absence of effective demand rather than a scarcity of supply. The shortage of finance, technical skills, and access to markets for their products prevents people from mobilizing the energy resources already available. The low level of energy use, being a symptom rather than a cause of the poverty in which people live, requires a simultaneous creation of demand and supply to relieve it. Conditions will not be improved by simply widening the technical opportunities for supply.

Effective energy demand will manifest itself by a widespread and diversified pattern of energy consumption. Its absence is evidence that the developmental process is at an early stage and that almost certainly the highest priorities are not yet in new forms of energy. Since renewable technologies are generally less versatile, more expensive, or more demanding in repair and maintenance than conventional technologies--compare for example the availability of mechanics able to repair a windmill with those who can tackle a diesel engine--the chances of their successful introduction as a cutting edge of development are less than in the case of conventional technologies.

New and renewable energy sources have acquired a special symbolic significance within the developed countries, which prevents them being viewed with the economic and technical detachment used when evaluating motor cars, dishwashers, and railway locomotives. One result is that too much attention is paid to new and renewable technologies as ele-

ments in the energy strategies of developing countries. The visiting energy experts, or the delegation from an international aid agency, are driven two hundred kilometres to see the country's two working biogas pits or a solar pump, as if these were items of major importance. Growing a few trees, harnessing a pair of bullocks, or training a single motor mechanic in tuning motor vehicles for fuel economy would have a far more beneficial effect than most of the renewable energy gadgets now being promoted for use in developing countries.

The projection of western "post-materialist" aspirations upon societies which have not yet achieved the minimum material requirements of dignified human existence is insidious and dangerous. At its worst it leads to a diversion of developing country resources into ill-conceived programs of renewable energy hardware. The energy problems of developing countries are too serious for any romantic preconceptions about certain technologies to distort the way in which the problems are analyzed or prejudice the solutions to be attempted.

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The Ten Commandments of Renewable Energy Analysis

David French

[This paper presents a series of 10 analytical "commandments" intended to guide the global community of planners and energy professionals in their search for new sources of renewable energy, especially for the poor. The emphasis is on finding new systems which must fit socially and economically as well as technically if they are to do more good than harm. The search for new systems of renewable energy must be "reality-led" rather than "technology-driven."]

By common agreement, the poor are in need of renewable energy. How can we best help them meet this need?

First, a note on the parties involved in this presentation. In the renewable energy business, "we" are the global community of planners and energy professionals. Citizens of both developed and developing countries, we have in common that our livelihood is provided to us in return for our work on energy problems. "They" are the reason for our work, the billions of poor who encircle the world. In energy terms, their common attribute is a need for dramatically improved access to energy as a condition for future survival.

Technically speaking, there is a wide array of new energy systems which could be applied to the daily tasks of the poor: improved wood stoves and charcoal kilns; more efficient tools; pumps and grinders run by hand, foot or animal; family woodlots; biogas and ethanol plants; windmills; electrical systems powered by photovoltaic cells, Rankine cycle engines, or mini-hydroelectric generators; pyrolytic converters to make char

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and oils from agricultural wastes; and on and on. If the availability of technology were the only energy issue, there would be little reason for concern.

But a new system must "fit" socially and economically as well as technically if it is to do more good than harm. It can be difficult for us to judge this fit, since we and the poor inhabit such different energy worlds. For us, energy means electricity and petroleum for running our cars, stoves and air conditioners. For them, energy is mostly firewood and charcoal for cooking, along with muscle-power for planting, hauling water, and grinding grain. If we are to help, we must somehow bridge this experiential divide. In so doing, we will do well to observe the analytical "commandments" now set forth.

Commandment 1: First, Do No Harm

In the 1980s, experts from an economic assistance mission came to a small Sahelian village. To prepare food, village women either pounded grain by hand or carried it to other villages nearby, where entrepreneurs ground it in diesel mills. Soon, the experts had installed an electric mill powered by an array of photovoltaic cells. The project was intended to find ways of freeing women's time for activities more "productive" than milling grain, while avoiding dependence on diesel fuel.

The project had unexpected results. Extra time was used for socializing, not "productive" activities. Ties with neighboring villages, where grain had been ground for a fee, were supplanted by ties with photovoltaic experts from abroad. As opposed to the old, egalitarian trading relationships, these new ties involved a one-sided dependence on the "superior" knowledge of the technicians. Disruption was accentuated when the outsiders turned over important management functions to the "logical" villager (a young technical school graduate) instead of the council of elders.

In short, the Sahelian grain mill finally offered relatively little of value while doing considerable harm. Social roles, bonds between villages, and habits of self-reliance were undermined. Irritation spread as the operator of the system seized the opportunities it offered for personal enrichment. Demoralization and anti-social behavior began to emerge, especially among young women lacking new work with social value equivalent to the grinding of grain. And so on.

In energy circles, it is sometimes argued that development is necessarily disruptive, and that we should not worry unduly about our contributions to the process. The argument is a bit suspect on the face of it, since it is always we who disrupt and the poor who are disrupted. Moreover, as the example suggested, disruption is often

harmful by any measure. The dangers are sufficiently great that a basic principle of our profession must be: "First, do no harm."

Commandment 2: Be Reality-Led, Not Technology-Driven

To be more useful than harmful requires us to understand the environment in which we are working. Our line of inquiry should be this: how do we open channels of communication between us and the poor? Given what we then find of their sense of needs and priorities, is there anything we can do to help? Such an approach allows energy planning to be "reality-led," emerging from the actual conditions of specific people.

Given the nature of our lives, however, there are constant pressures to disengage from the poor and to deal primarily with each other. Since technology is what we understand best, we look for technical problems and try to solve them. As opposed to being reality-led, this approach becomes "technology-driven." Unfortunately, the problems we are thus driven to consider may not be the problems the poor think they have.

In practice, of course, all of us are both reality-led and technology-driven in varying proportions. Measured against outside "experts," officials of developing countries are relatively reality-led; but even they are not immune from the inner struggle between these conflicting tendencies. As the later commandments make clear, the struggle recurs in all the things we do as energy practitioners. Point by point, if we are to succeed, we will need to nurture the more reality-led of our professional perceptions.

Commandment 3: Filter Your Data Well

One important way of measuring reality is the energy survey, a data-gathering exercise which can help lead us to correct action at the local level. To fulfil this role best, such a survey ideally would proceed as follows:

(1) First, we would determine what the people being surveyed thought were their most pressing concerns. From this list, we would abstract those concerns (if any) which had clear energy implications.

(2) Second, where energy needs were pressing from the local point of view, we would call to mind the systems which on technical grounds might meet these needs.

(3) Third, we would gather the additional local data required to cast light on our candidate systems. These data would be "filtered" through analytical screens (see later) to predict whether our systems would make sense on social and economic as well as technical grounds.

(4) Fourth, we would observe the performance of systems chosen for testing in order to refine our knowledge of local reality. (This kind of observation is sufficiently important that it is the subject of "Commandment 9: Keep Track of What You Do.")

In practice, this process may require too much dialogue to meet our need for rapid identification of project opportunities. As a result, energy surveyors may simply proceed to gather all data which might bear on any possible technical response to any possible local problem. This will be enormously wasteful, since it implies collecting masses of information which in no way relate to the needs which people actually have. Nonetheless, we can still observe the analytical sequence outlined earlier, abstracting at each step those data which apply.

Central to this process are the analytical "filters" through which we pass raw data to determine whether systems being considered are socially and economically appropriate. For example, the correct economic filter is benefit-cost analysis, which allows us to judge whether we will get as much out of a system as we put into it (see Commandment 4). Since different analytical filters require different kinds of data, no survey should be set in motion until we know which filters will be used. Only then can we know which data we need to collect.

The survey approach outlined here is reality-led. Most energy surveys, however, are technology-driven. In such a process, measurements are taken of the energy now being used and of alternative sources which are locally available. We ourselves determine local "needs" (read "technological opportunities") and set out to test whatever devices might be made to work. If the wind blows, we install windmills; if the water flows, we import hydroelectric units; if the sun shines, we build solar cookers. Throughout the developing world, the abandoned carcasses of energy systems chosen in this way testify to the bankruptcy of the approach.

A final point. In stressing that surveys must center on needs, as now perceived by the poor themselves, we do not imply that needs are unchanging. People who appear unworried by energy matters today may be deeply troubled in another 5 years. Nonetheless, such changes of heart are unlikely to come through persuasion by us energy outsiders. If our surveys find people who do not now share our concerns, we should go elsewhere. We can always come back later, and we will not lack for things to do in the meantime.

Commandment 4: Find Net Present Value

The best model we have for the way individuals view economic decisions is benefit-cost analysis. Such analysis rests on two

intuitively obvious assumptions. First, we take for granted that people who buy a system will expect to receive more resources from it (benefits) than they put into it (costs). Second, we assume that people will attribute different values to given flows of benefits (or costs) depending on when these take place: today, next year, or 10 years from now, with future values discounted because present values are closer and more certain.

Properly handled, information on these points tells us the system's "net present value" to the individual. (That is, after discounting the values of future benefits and costs to make them into present values, the excess of benefits over costs is estimated.) If net present value is positive, the system is worth its cost; if net present value is negative, it is not. With appropriate adjustments, the same approach can be used to find the system's net present value from the perspective of society as a whole.

Although benefit-cost analysis is widely applied in the modern sectors of developing countries, this experience can be transferred only with the most extreme care to the poor. Point by point in our analysis, we must work to unfold <u>their</u> reality, rather than express our own.

At the most obvious level, this means ensuring that we attach their numbers to key variables. For example:

(1) <u>Benefits</u>. In many cases the quantifiable benefits of a new system will simply be the value of the energy it replaces. For someone using an electric stove, the benefits of shifting to biogas would be equal to the cost of electricity which would then not have to be used. For someone cooking on an open fire, biogas would be worth the cost of twigs her children would no longer have to collect. A system's net present value will vary greatly depending on whether benefits are measured in terms of electricity or twigs. To predict a system's economic appeal, we must therefore be sure we know which forms of energy the potential buyer now uses.

(2) <u>Operating life</u>. Net present value of an energy system depends heavily on the lifetime and maintenance costs we expect for it. All too often, we anticipate that a system's performance in rural areas of developing countries will be similar to performance in developed countries or in research labs. This is a mistake.

(3) <u>Discounting</u>. "Discounting" is a technique for measuring the value of having a dollar next year as compared with having a dollar today (reducing future values by a certain percentage for each year). We and the poor are likely to attach very different values to next year's dollar. This fact is important enough in itself that it is the subject of "Commandment 5: Set Your Calendar to Local Time."

Our tendency in estimating these values is to bend them in favor of the technologies under review. In the absence of local data, for example, we tend to extract numbers from our own reality for purposes of analysis. In key instances (benefits, discount rates, operating life) our numbers will be systematically more favorable to new technologies than would local values. The problem is compounded by the fact that the people carrying out such analysis (manufacturers, consultants, energy bureaucrats) often have a strong vested interest in showing that the systems they prefer are sound. Together, these distorting forces can easily encourage us to support systems with no prospects for success in the real world.

Sometimes, "cost-effectiveness" is proposed as a way to judge the economics of energy systems. When comparisons of the costs of producing energy benefits are used to justify a project, it is important to be sure that the energy systems being compared are realistic possibilities. If, for example, a solar pump is being promoted as more cost-effective than a diesel or electric pump would be, this is no justification of the solar system in conditions where neither the diesel nor electric alternatives would be practical possibilities in any case.

Commandment 5: Set Your Calendar to Local Time

When we travel across the world, we adjust our watches to local time. When we try to cross the psychic distances between us and the poor, we must do the same to our calendars. The issue here is not what year it is, but how far away the future seems. For us, next year may appear imminent, the year after close behind. The consciousness of an impoverished villager, on the other hand, is likely to be focused more closely than our own on a precarious present, the years ahead receding rapidly from view.

This matters most when we try to decide how heavily the potential buyers of an energy system will "discount" the portion of its benefits which will only be gained in future years. For example, we may assume that buyers consider having $1.00 a year from now to be the same as having $0.91 today. This implies a "discount rate" of 10%, a figure often used in benefit-cost analysis because it is a round number somewhere within the range of discount rates we seem to apply to our own economic decisions. The poor, however, may have discount rates far higher than this. For example, $1.00 next year might be viewed as having the same value as only $0.77 (or less) in hand today. This would imply a local discount rate of 30% (or more).

Although the correct discount rates for the poor are not easy to establish, economic theory suggests they will be roughly equivalent to interest rates on local loans. Outside of urban areas, the relevant rates would be those charged by nonofficial sources of credit, like

merchants and moneylenders. Following a study of such credit, the World Bank found that interest rates averaged more than 32% in real terms world-wide. As a first approximation of reality, we might therefore assume that the average country-dweller in the developing world will apply a discount rate of at least 30% in considering energy investments.

This fact becomes critical when we compare capital- and labor-intensive ways of doing the same energy job. Capital-intensive systems (solar cells, hydroelectric installations) typically pile heavy investment charges into the first year, with compensation in the form of substantial benefits in later years. At high discount rates, where the value attributed now to future money is dramatically reduced, it may be difficult to compensate for initial costs. Labor-intensive devices (pedal-power or animal-driven systems) seldom involve as much early red ink and are therefore less vulnerable to the impact of discount rates on reduction of future benefits. Of two competing devices, the most capital-intensive may therefore have a higher net present value where discount rates are low; where discount rates are high, the more labor-intensive system may prevail.

The use of our discount rates to measure their realities is strongly associated with a technology-driven approach to energy analysis. Since most of the technologies that drive us are capital-intensive, we require low discount rates to justify what we do, no matter how fictitious these rates may be. A reality-led approach, by contrast, will start by finding what discount rates are among the poor. While a wide variety of systems may prove justifiable using these rates, we are likely to be forced into considering systems much cheaper and more labor-intensive than those to which we are accustomed in our own world. Such are the implications of setting our calendars to local time.

Commandment 6: Master the Unquantifiable

Energy systems may have effects which are not readily measured or expressed in numbers. Examples might include:

(1) Ecology. A renewable energy system which reduces demand for firewood will save trees. This will keep watersheds healthy, which will conserve topsoil, which will help maintain agricultural productivity. Where dung is used for cooking, improved stoves will leave more dung in the fields, allowing nutrients to be restored to the soil. Although such effects may be an important aspect of energy systems, they are very hard to isolate and weigh.

(2) Health. Improved stoves often incorporate chimneys, meaning that smoke need not accumulate inside the home. Especially where dung

is used for cooking, the smoke-free environment which results may significantly reduce respiratory and eye disease. If human wastes were fed into biogas systems, pathogens (germs) would be destroyed which could otherwise pose a threat to public health. Again, such effects are important--and all but impossible to measure.

(3) Development. In addition to providing irrigation water, a pedal-powered pump might call forth a local capacity to make, assemble and repair important parts. To finance and manage a photovoltaic pump, a community might need to create an energy co-operative. In either case, the technical or organizational skills acquired could speed the pursuit of other development goals.

An energy system may have negative impacts as well: termites could spread in houses cleared of smoke by improved stoves; schistosomiasis could appear in the impoundments behind mini-hydroelectric installations; and so on. Most energy systems are likely to have unquantifiable effects which range from relatively neutral to strongly positive. This will simply strengthen the case for systems which are also sound on quantifiable grounds--that is, which have proved to be superior using benefit-cost estimates. Where a system is terrible by measurable criteria, however, analytical problems may arise; how compare a numerical "no" and a numberless "yes"?

To master the issue, a first step is to be sure that any unquantifiable benefits attributed to a system actually exist. Attempts are sometimes made to justify family biogas plants, for example, on the basis of the pathogens they remove from wastes. However, the biogas process increases the volume of untreated dung which people are routinely forced to handle, so that health benefits claimed for the system are open to question.

Where unmeasurable benefits are real, benefit-cost analysis can at least indicate how great their value would have to be for a system to be worthwhile. For example, consider a hypothetical $60 stove which burns dung more efficiently and vents the smoke outside the dwelling. The stove's most obvious benefit from the investor's point of view might be labor worth $15 annually which is freed from dung collection. An added, unquantifiable benefit would be improvements in health from no longer breathing dung smoke. Assuming a local discount rate of 30%, it involves a relatively simple calculation to find that health benefits would have to equal at least $4 annually for the stove to have positive net present value. The potential buyers can then be asked whether clearer eyes and lungs are worth more or less than $4 a year.

The approach we select for dealing with a system's unmeasurable qualities will vary both with the system and with the place where it

is to be tried. Nonetheless, there will almost always be some way in which the unmeasurable can be mastered--or at least better understood --for purposes of analysis. The discipline is a necessary one. In our more technology-driven moods, the hint of unquantifiable benefits may be used to dismiss the measurable and proceed with the system we wish to promote. When reality-led, on the other hand, we will find that unquantifiables simply add subtlety and spice to the process of finding how to meet the needs of the poor.

Commandment 7: Be Replicable

A single renewable energy system--a pump, a stove, a woodlot or a solar cell array--will in itself make but a trivial contribution to a country's energy needs. It is only when a system is adopted by the thousands (or hundreds of thousands) that significant impact will be felt. From the earliest stages of conceiving and testing such systems, we must therefore consider what would happen if they were widely replicated.

There are two major tests of replicability:

(1) Net present value. As noted in Commandment 4, an energy system should produce more resources over its lifetime than it consumes--that is, its net present value should be positive. When this criterion is met, the more of such systems the better. If the system fails this test, on the other hand, a program to promote its use will magnify the net present harm it does to society.

(2) Claims on national resources. At the pilot stage, the testing of almost any new system will require an unsustainably heavy infusion of human and financial resources. Beyond this stage, however, systems will differ greatly in the amounts of personnel and money which governments would have to provide to support their use. In some cases, claims on scarce resources would simply be too great to consider, whatever the system's apparent advantages.

These principles are fairly obvious--and commonly ignored in development practice. In terms of claims on national resources, many pilot woodlots demonstrate how not to be replicable. At least until very recently, a common model for village woodlots involved 10 hectares of land, a process for planting seedlings there, and a barbed wire fence to keep out the goats. Unfortunately, to extend this model broadly enough to meet the fuelwood needs of a representative developing country could cost so much for the barbed wire that it would not be replicable in terms of available resources, a point that was often neglected until demonstration woodlots of this sort had been planted around the world.

There is an important inference to be drawn from this example. In many energy areas, there may be considerable room for substitution between local capabilities (a commitment by goatherds to stay out of the woodlot) and central resources (the purchase by governments of barbed wire fencing). The technology-driven instinct is to import fencing rather than try to mobilize goatheards. Even assisted by the international aid community, however, no government of a developing country has either the cash or the staff to address by itself the total energy needs of its poor. To a considerable degree, therefore, "replicability" may simply measure the extent to which the resources of the poor themselves will be mobilized by a new energy idea.

If this be true, we need hardly add that systems are more likely to be replicable if they evolve from a reality-led selection process, rather than being driven into our lives by their technical appeal alone.

Commandment 8: Provide No Subsidies

Subsidies are the opiate of the energy programmer. It is possible to sustain a bad system almost indefinitely with subsidies sufficiently large that the system need never be judged on its merits.

The very possibility of subsidies is often enough to preclude critical thought. In discussion of energy systems, the effect takes characteristic forms:

(1) If it works, subsidize it. With some variations, the basic case for subsidies runs as follows: since the system under review makes energy in new forms which people might be convinced to use, its distribution should be subsidized. Here, economic and social feasibility are simply ignored.

(2) Good money after bad. A more sophisticated argument states that since governments (ours, theirs, anybody's) have already subsidized electricity and petroleum products, governments should subsidize renewable energy systems. If the earlier subsidies followed from analysis of their social, economic and technical implications, the same kinds of analysis should be applied to new systems as well. On the other hand, if the earlier subsidies were not based on such analysis, we have no reason to suppose they made any sense in themselves. In this case, we should certainly not seek to throw good subsidy money after what is probably bad.

(3) Circular reasoning. Very often, a purportedly favorable analysis of an energy system's economic appeal will be based on an interest rate of 5-10%. As noted later, however, rural credit on such terms is heavily subsidized. Having thus assumed a subsidized device,

the analyst uses the results as a justification for subsidies. This circular form of argument has the advantage of allowing us to justify any system we want, simply by building subsidies into interest rates or other data until we get the returns we need.

Formally speaking, of course, we can outline conditions where subsidies for an energy system would be warranted. The criteria are: (1) the system must have positive economic benefits for society as a whole, and these must be greater than benefits provided by competing systems; (2) the system must depend on subsidies to lower its cost (or increase its returns) in order to appeal to investors; and (3) the necessary subsidies must be more attractive to the government involved than spending the same money on other development activities.

In the real world, however, almost no energy system will meet all these tests. If the system has value for the society, it is likely also to appeal to private investors. If it does not sell commercially, it will probably be also unsound from the national point of view. There may be instances where subsidies are warranted, but these are very, very rare.

None of this is to argue that governments should provide no support at all for new energy systems. As long as Commandments 1-10 are carefully observed, there is great scope for governments to conduct energy surveys, design or modify new systems, estimate their social and economic feasibility, carry out tests of pilot units, train energy extension workers and so on. "Provide no subsidies" simply means that the systems which are the focus of all this activity should be expected quickly to stand on their own, without the reality-evading props that subsidies provide.

Nor does anything here argue against the provision of credit for the purchase of energy systems. However, credit should not be a disguised form of subsidy. The World Bank estimates that "real" costs of providing rural credit (adjusted to eliminate inflation) may be 22% annually even for efficient lending institutions. There is no reason whatever that potential investors in new energy systems should not be expected to cover these costs. In other words, credit should simply be a way of enabling capital-poor investors to buy inherently attractive devices; it should not be used to give false sheen to the nonviable.

In sum, subsidies are the last refuge of the technology-driven. If the system we choose to promote cannot stand the test of reality--or if we simply prefer to avoid this test--we can always subsidize. Almost always, however, such subsidies cause both us and the poor to divert time and money to systems which either need no support or deserve none, while systems with real-world appeal are ignored.

Commandment 9: Keep Track of What You Do

A great many renewable energy technologies are now being tested in developing countries. Unfortunately, such tests almost always address strictly technical questions: do the woodlots grow wood? do the pumps pump? do the grinders grind? Very occasionally, cultural or economic questions are also asked, although the asking is rarely more than perfunctory. In line with the technology-driven nature of energy programming, it is the technical performance of our systems that holds most of our attention.

It is not enough to know if our systems work, however. We need to find if they make sense to users, and that is more complex. In addition to collecting technical information, our tests must therefore address the following points:

(1) Economic. A system makes economic sense if it has positive net present value. To determine whether this criterion is met, we need various kinds of local information, ranging from wage rates and unemployment levels to materials costs and interest rates. As necessary, we can adjust test data to suggest what costs and benefits would be if the system were more widely distributed.

(2) Cultural. If it is not to be shed when the technicians depart, a system should be in rough accord with local sex roles, land tenure patterns, forms of cooperation and authority, work habits and the like. The survey process outlined under Commandment 3 should show whether a given system is likely to meet these conditions; the pilot test should confirm whether this is so.

(3) Administrative. The implementing ministry for the test should be one (agriculture, rural development) with established extension links to the poor. By involving trained extension workers, we will help ensure that the right information is fed into the monitoring process. We will also find whether the ministry has the technical skills which would be required of it if the decision was ultimately made to spread the system generally through the land.

Real information on these matters can be acquired only if the system being tested is woven fully into the lives of real people. This requires that people, government and (where relevant) donor agree in advance on key elements of the test. Points to be covered include these: What are the goals of the test? Where will it take place? Who is to participate? Who is to contribute work, money, maintenance, supervision, equipment and land? When will these contributions be made? Who will receive the benefits of the system? What payments (if any) will be made for these benefits, and to whom? Who will keep any equipment once the testing period is over? How will any disputes arising from the above be resolved?

Once the experiment's basic structure is established, progress should be closely monitored. Regular meetings should be held by a monitoring committee comprised of representatives of the ministry (including both headquarters and field staff), the people actually using the systems, any donor agencies involved, and qualified observers with no immediate interest in the project. The administering agency would keep records of the committee's proceedings.

As the experiment proceeds, it may prove desirable to redesign various elements of the system, adjust the ways in which it is being managed, correct inequities in the distribution of benefits, or otherwise respond to the unforeseen. Monitoring of the sort outlined earlier can ensure that problems are caught early, that responses are based on current local information, and that the results are recorded. More than incidentally, the process also ensures that all the parties concerned are involved in doing these things.

As outlined here, the monitoring process may seem too demanding for government officials already stretched thinly across their work. Nonetheless, the above are minimum conditions for ensuring that a test is properly conducted and its results fully known. In practice, the alternative is usually to leave evaluations to the people whose device is being considered. This is worse than no test at all, however, since it gives an illusion of objectivity to a process of self-promotion. If we are unable to keep track of what we do, we are better off doing nothing.

Commandment 10: Think Small

Scattered throughout the earlier commandments is the admonition to be "reality-led." The relevant realities, we might add, are seen only when our vision is narrowly focused. To "filter your data well," for example, requires us to understand the specific outlook of the particular people we survey. Similarly, to "set your calendar to local time" or to "master the unquantifiable" implies a very concrete sense of local realities. Large thoughts may follow about energy policies and programs, but such thoughts will be correct only if their origins are small.

We should also think small in terms of the energy technologies we support. When these devices are analyzed using numbers from the real world, there appears to be a direct relationship between their simplicity and their economic merit for the poor. Small systems also seem to have greater developmental impact, in terms of those unquantifiables which register an area's capacity for healthy future growth. Complex devices will sometimes be appropriate, of course. Nonetheless, relative to a technology-driven view of things, a reality-led spectrum of energy systems will be weighted much more heavily toward the simple and the cheap.

Finally, we must think small in terms of what we can achieve. In energy terms, the world's poor are now undeveloping. Practically everywhere, firewood has begun to disappear. Overworked land requires more energy to produce the same amounts of food. Water must be moved from farther away or from deeper underground to meet the growing needs of crops, livestock and people. Instead of becoming available to replace traditional energy supplies, petroleum is being priced permanently out of reach. Together, these problems simply dwarf the resources we bring to the search for solutions.

Ultimately, "our" role can be no more than catalytic. At most, we might supply a few bright ideas and some marginal infusions of money to support the energies of the poor. Only by being scrupulously reality-led can we know which way the poor are leaning and what little we can do to help. If we could but learn to take a step that small, how great our progress would be.

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Field Testing of Energy Technologies for Decentralized Low-Power Applications in Developing Countries

Stephen Klein

[New energy technologies for rural uses should be carefully field tested with information collected in standardized fashion on a range of factors that can affect the replicability of the systems.]

The Problem

A number of new energy technologies are or will become economic for low-power rural uses in developing countries over the next five to ten years. The likely feasibility of these new systems results from intensified research and development sparked by the significant increase in oil prices since 1973.

New technologies will not be adopted on a large scale, however, until they are proven effective in operational settings in developing countries. Potential users must be able to assess the risks as well as the benefits before they make investments in a new system. To accomplish this will require decision makers (public and private) to have hard facts on the economic, technical, social, and institutional aspects of the operation of the system over an extended period of time.

The Present Situation

During the past few years, "demonstrations" of new systems (primarily renewables) have received substantial attention in the effort to provide alternatives to the fossil fuels which people fear will become costly or simply not available. Proving that a technology operates has been the chief objective of these demonstrations, so

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as to overcome resistance by buyers based on their assumed ignorance of the system. These demonstrations, however, have overlooked other important conditions for the adoption of a new system. These include: (i) identification and collection of information essential to assessing whether the system will be a good investment, especially information on economic, financial, social/cultural and institutional factors; (ii) methods for comparing results from different sites to determine broad applicability; and (iii) consideration of how extensive use would actually start once the demonstrations were completed. In addition, many demonstrations have been "successful" when expatriate advisors bought and supervised the operation of imported equipment, only to result in "failure" when the advisors left.

When program evaluators have visited demonstration sites, they have been frustrated by the absence of any framework of criteria against which to evaluate success or failure, and by the lack of critical information collected in systematic fashion. There has been too much concentration on technical operation, and too little on the broader lessons to be learned.

The Field Testing Program

Carefully structured and scientific testing programs are needed to test new energy technologies for decentralized low-power applications under field conditions. These programs should be designed to apply professionally developed approaches that would assure a comprehensive information feedback on the operation of the new technologies.

Three steps should be taken to implement the field testing programs:

1. Identify the significant end-uses in rural areas. The use and importance of energy in rural areas is not well understood, primarily because reliable data are not available. National energy planning typically has concerned itself with those aspects with which people are most familiar and for which analytical techniques have been tried, such as the electricity sector, urban transit, industrial consumption, and oil/gas imports. The rural sector has usually been ignored because (i) analytical techniques are still evolving, (ii) concern with rural energy, aside from rural electrification, is a relatively new phenomonon, and (iii) it appears to be of lower political concern, since commercial energy comprises a minor percentage of total rural energy use. The number of rural energy surveys is now expanding and the data gap is being filled, but a more concerted effort to pull together this information is still required.

Rural energy analysis should produce a better understanding of the most important energy end-uses in rural areas. The key questions to be

addressed are two: First, what is the composition of the major end-uses for households (cooking, lighting), for agriculture (irrigation, fertilizer, processing, transportation), for industry (electricity, processing), and for transport? Second, what types of energy best meet these end-uses (e.g., electricity, process heat, shaft power or transport fuels)?

2. Select those technologies with the best economic potential (without subsidies) to meet the most significant end-uses. This step should match those technologies likely to be economic over the next five to ten years with the important end-uses, thus assuring that the systems to be tested will make a real difference to development efforts rather than be economic only for a narrow band of applications.

The selection process should include a review of petroleum-based systems, even though they have been criticized as ill-suited and expensive for low-power applications. A research and development program to develop improved petroleum-based systems for low-power applications could be an important option.

3. Test the identified technologies in operating conditions under a standardized system for collecting, analyzing and distributing information on field performance. Several different information criteria and systems will be required for the varying sets of technology/end-use combinations, given the diversity of energy endowments, technologies, and required end-uses. It is extremely unlikely that any one technology will be applicable to meet all energy end-uses in most situations.

In selecting field sites, consideration should be given to whether the technology has been proven in laboratory testing, the management capability of the country's institutions (again public and private), and the degree of private sector involvement. Up to now private firms have not been extensively involved in field testing. Nonetheless, a selected technology should have market potential because private individuals or firms are the most likely implementing agents for any wide-scale use.

A major constraint to effective field testing programs is the lack of professionally acceptable evaluation criteria on the operation of a particular technology for a particular end-use. This deficiency is attributable more to the incipient testing stage of the technologies in question than to irreconcilable professional differences; in most cases researchers are just beginning to explore the criteria and measurements for field testing programs. Significant progress has been made recently in establishing common criteria for gasifiers (Netherlands, Sweden, World Bank), woodstoves (AID, Netherlands, U.K., France), and biogas (AID, Japan). Further progress on an international scale should be supported.

A field testing program should include the following procedures:

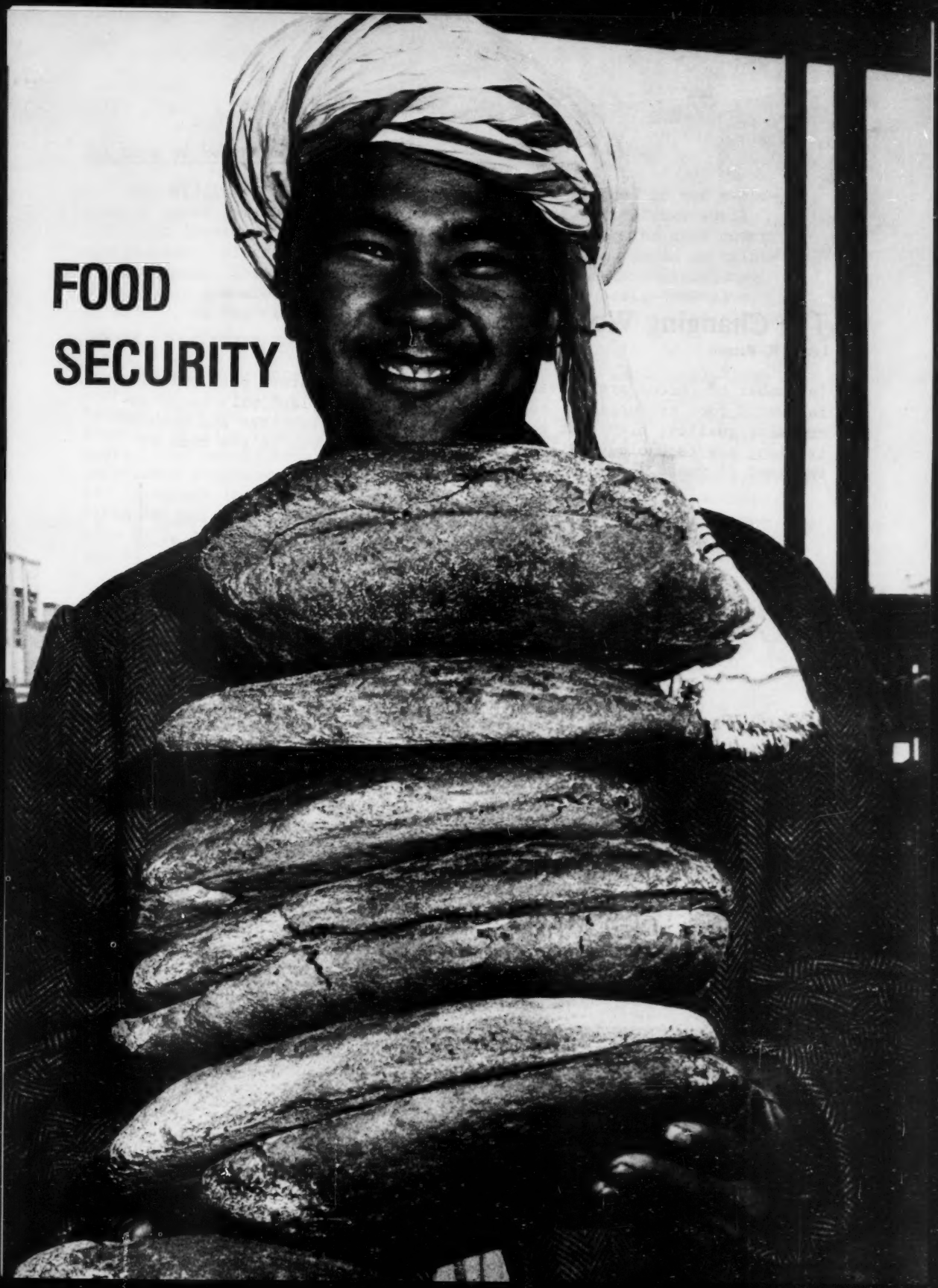
a. Common sets of information elements should be established and specified for the technology/end-use combinations selected for field tests. Such pre-established criteria will enable comparison of the same technology/end-use combination from different sites, both within a country and among countries. Individual researchers may decide to collect additional detailed information on a particular application, but at least a common standard will exist that can be followed. In addition, this step will also encourage better evaluation because the implementor has criteria to adapt to his or her particular needs instead of creating an evaluation/feedback system *de novo* for each individual activity.

b. A collection system should be established for assembling information obtained from field tests of each technology/end-use combination. Collection can be done by national, regional or international entities that have the needed capability in the particular field.

c. The collecting entity should analyze, interpret, and disseminate the field test results of participating programs. Over a period of time, information would evolve on economic, technical, socio-cultural and institutional factors affecting the use of the new technology as a prelude to widespread replication.

d. Finally, care and thought should be given to ways of comparing information about different technologies aimed at a single end-use, for example, how to compare wind pumps, photovoltaic pumps and traditional pumping methods for irrigation.

[An original article.]


FOOD
SECURITY

The Changing World Food Prospect

Lester R. Brown

[A number of forces are converging to restrict the future possibilities for world food production: additions to cultivated land will be of decreasing quality; high cost energy limits use of fertilizer and mechanization; new technology will not support output growth at the rate of the last 25 years.]

Each threat to the sustainability of society--cropland degradation, the deterioration of basic biological systems, and the depletion of our global petroleum inventory--affects the food prospect. Anything that shrinks the cropland base or reduces its inherent productivity makes eliminating hunger harder. Overfishing and overgrazing directly affect the long-term food supply, while deforestation affects it indirectly by accelerating erosion and by forcing Third World villagers to burn cow dung and crop residues for fuel. The era of cheap oil that helped underwrite the explosive growth in world food output during 1950-75 is now history, and the need to shift to alternative energy sources is setting up a new competition between the energy and food sectors for agricultural resources.

As these pressures converge, the worldwide effort to expand food production is losing momentum. The grain surpluses accumulated in food-exporting countries during the fifties and sixties have disappeared. Idled U.S. cropland has been returned to production, world food supplies are tightening in overall trends; and the slim margin between food production and population growth continues to narrow.

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The Loss of Momentum

The middle of the twentieth century was a watershed in the evolution of world agriculture. From the beginning of agriculture until 1950 most increases in food output came from expanding the area under cultivation. Since then, most have come from raising yields on existing cropland. Chemical fertilizers, irrigation, and mechanization--the primary means of expanding production--are all energy-intensive. In effect, as the frontiers disappeared, farmers learned to substitute energy for land.

The disappearance of frontiers notwithstanding, mid-century also marked the beginning of an unprecedented growth in food production. Between 1950 and 1971, the world's farmers increased grain production from 631 million tons to 1,237 million tons (see Table 1). In just 21 years, they nearly doubled output. In per capita terms, there was impressive progress: world cereal production per person climbed from 251 kilograms in 1950 to 330 kilograms in 1971, a gain of 31 percent. Diets improved measurably in many Third World countries, and consumption of livestock products climbed steadily throughout the industrial world.

Table 1. World Grain Production, Total and Per Capita, 1950–80

Year	*Population*	*Grain Production*	*Grain Production Per Capita*
	(billions)	(million metric tons)	(kilograms)
1950	2.51	631	251
1960	3.03	863	285
1970	3.68	1137	309
1971	3.75	1237	330
1972	3.82	1197	314
1973	3.88	1290	332
1974	3.96	1256	317
1975	4.03	1275	316
1976	4.11	1384	337
1977	4.18	1378	330
1978	4.26	1494	351
1979	4.34	1437	331
1980 (prel.)	4.42	1432	324

Source: U.S. Department of Agriculture and United Nations.

Since 1971, however, gains in output have barely kept pace with population growth; production per person has fluctuated widely but shown little real increase. The long postwar period of food-price stability came to an end with the massive Soviet wheat purchase in 1972, which signaled the beginning of a new era. Within months, the world price of wheat had doubled and famine had returned to the Indian subcontinent, Africa, and elsewhere after a quarter-century absence. As food prices have climbed, diets have deteriorated in some Third World countries, especially among landless laborers and the urban poor. In some industrial societies, tightening grain supplies have led to a drop in per capita consumption of beef and other livestock products.

Shortfalls in harvests prevented until 1976 a rebuilding of the world food reserves depleted in 1972. With some uncommonly good harvests in the late seventies, the food situation then stabilized temporarily. But in 1980, a poor harvest in the Soviet Union and a mediocre one in the United States resulted in a drawdown of world food reserves to a near-record low. Inefficient agrarian structures, soil erosion, the conversion of prime cropland to nonfarm uses, the falling yield response to chemical fertilizers in the agriculturally advanced countries, and rising energy costs--all contributed to the slower growth in food output.

The North American Breadbasket

More and more countries in which grain production has not kept pace with demand have come to rely on North America's exportable surplus (see Table 2). Prior to World War II, Western Europe was the only grain-importing region. North America was not the only exporter nor even the leading one; in the late thirties, Latin American grain exports were nearly double those of North America, and Eastern Europe (including the Soviet Union) was exporting the same amount. All this has now changed beyond recognition. Asia has developed a massive deficit. Africa, Latin America, and Eastern Europe all import food. Western Europe, consistently importing 15 to 30 million tons, has been

Table 2. The Changing Pattern of World Grain Trade*

Region	*1934–38*	*1948–52*	*1960*	*1970*	*1980*
	(million metric tons)				
North America	+ 5	+23	+39	+56	+131
Latin America	+ 9	+ 1	0	+ 4	− 10
Western Europe	−24	−22	−25	−30	− 16
E. Europe and USSR	+ 5	0	0	0	− 46
Africa	+ 1	0	− 2	− 5	− 15
Asia	+ 2	− 6	−17	−37	− 63
Australia and N. Z.	+ 3	+ 3	+ 6	+12	+ 19

*Plus sign indicates net exports; minus sign, net imports.
Source: Food and Agriculture Organization, U.S. Department of Agriculture, and author's estimates.

the most stable element throughout the period. North America's emergence as the world's breadbasket began in the forties. The scale of exports expanded gradually during the fifties and sixties, then more than doubled during the seventies as scores of countries began to lose the capacity to feed themselves.

This dramatic transformation of intercontinental food flows reflects wide differences in population growth, widely varying levels of agricultural management and, in many countries, a rate of soil erosion that is draining cropland of its fertility. As recently as 1950, for example, North America and Latin America had roughly equal populations --163 and 168 million, respectively. But while North America's population growth has tapered off substantially since then, Latin America's has escalated. Mexico, Venezuela, Peru, and Brazil all have population growth rates of close to 3 percent per year. Had North America's 1950 population expanded at 3 percent per year, it would have reached 395 million in 1980 rather than the actual 248 million, and absorbed virtually all the region's exportable surplus.

Today, over a hundred countries rely on North American grain. The worldwide movement of countries from export to import status is a much travelled one-way street. The reasons vary, but the tide is strong: no country has gone against it since World War II. Literally scores of countries have become food importers and the degree of reliance on outside supplies is growing. Among the countries that now import over half of their grain supply are Algeria, Belgium, Japan, Lebanon, Libya, Saudi Arabia, Senegal, Switzerland, and Venezuela. Other countries rapidly approaching primary dependence on imported foodstuffs include Costa Rica, Egypt, Portugal, South Korea, and Sri Lanka.

For most countries, the need for imported food is more likely to increase than decrease. Agricultural mismanagement and inefficiency has taken its toll on food production, particularly in the Third World and the centrally planned economies of Eastern Europe. It is difficult, for example, to see how the Soviet Union can avoid importing even more grain in the near future. In the late thirties, the Soviet Union and Eastern Europe still had a regional export surplus of several million tons of grain yearly. But since then, the food balance has slowly shifted. Throughout the sixties the Soviet Union teetered on the brink of food self-sufficiency, sometimes as exporter, sometimes as importer. But with Moscow's decision in 1972 to offset crop shortfalls by importing grain rather than by slaughtering the livestock herds, the Soviet Union emerged as a chronically food-deficient country. During the mid-seventies, grain imports averaged 9 million tons per year; later in the decade they were averaging some 20 million tons per year, and they began the 1980s by importing 31 million tons of grain in its first year, more than any country in history. Although the Soviet Union has the largest cropland area of any country, the inefficiency of its agricultural system represents a problem Moscow planners seem unable to solve.

Production on Soviet agricultural collectives and giant state farms cannot approach that of the family-farm system that dominates West European and North American agriculture.

Other countries also face rapidly growing deficits. Egypt has little opportunity for expanding its agricultural base and yet its population is growing rapidly. According to the International Food Policy Research Institute projections, Nigeria will have a food deficit of at least 17 million tons of grain in 1990 if recent trends continue. Mexican grain imports are growing by leaps and bounds, and this trend is likely to continue. The story is fundamentally the same in scores of countries.

Although the need for imported grain is projected to continue growing, the capacity of North America to respond to these demands may ultimately be overwhelmed. The disappearance of idled cropland, the growing use of U.S. grain in alcohol fuel distilleries, losses of top soil, and the projected decline in irrigated acreage in key farm states will all make it more difficult to sustain the rapid growth in North American exports on which the world has none too wisely come to rely.

Behind this trade issue, a philosophical debate is beginning to emerge on the wisdom of mining soils in order to meet the ever growing world demand. Many agricultural analysts and environmentalists now argue that it makes little sense for the U.S. to sacrifice a resource that has been a source of economic strength since colonial days merely to buy a few billion barrels of oil. Others contend that the current generation of farmers has no right to engage in the agronomic equivalent of deficit financing and thus mortgage the future of generations to come. The current trend is fraught with risks, both for those whose livelihoods depend on land being productive and for those in countries dependent on food imports that will dry up if the mining of soil continues.

Growing Food Insecurity

From the late forties through the early seventies, the world enjoyed an unprecedented period of food security. Carryover stocks of grain, held largely by the principal exporters, and cropland idled under farm programs in the United States accounted for that security. Grain carryover stocks--grain in bins when a new harvest begins--were available for use when needed. Idled U.S. cropland could be brought back into production within a year. Together, these two reserves provided security for all mankind, a cushion against any imaginable disaster.

As recently as 1969, the amount of grain that either was held in storage or that could be produced within a season on idled U.S. cropland amounted to 91 days of world consumption. But following poor harvests in key producing countries in 1972 and 1974, world reserves fell to only 40 days (see Table 3). At this level, grain stocks constituted little

Table 3. Index of World Food Security, 1960–80

Year	Reserve Stocks of Grain	Grain Equiv. of Idled U.S. Cropland	Total Reserves	Reserves as Days of World Consumption
	(million metric tons)			(days)
1960	198	36	234	102
1965	143	70	213	80
1970	165	71	236	77
1971	183	46	229	73
1972	142	78	220	66
1973	147	25	172	51
1974	132	4	136	40
1975	138	3	141	40
1976	192	3	195	55
1977	191	1	192	51
1978	228	21	249	62
1979	191	15	206	51
1980	151	0	151	40

Source: Worldwatch Institute, derived from USDA data.

more than pipeline supplies between the farmer and the ultimate consumer. For the first time in a generation, there is no cropland idled under U.S. farm programs and carryover stocks of grain in 1980 were again reduced to 40 days of consumption.

World food insecurity was exacerbated by the extension of agriculture onto marginal lands. While climate has changed little in recent years, the vulnerability to climatic anomalies is undoubtedly increasing. As meteorologist Kenneth Hare observes: "The Sahelian drought in Africa, for example, had several predecessors over the previous 500 years. What has changed is the vulnerability of the human economy." Although the Soviet "Virgin Lands" in Western Siberia are a major source of bread for Soviet tables, they are in an area of light and highly variable rainfall, subject to crop failure in one year of every three or four. When the decision was made in Moscow to offset these periodic shortfalls by increasing imports, the instability that had been confined to the Soviet food economy began to affect the supply and price of food for the entire world.

Soil erosion also contributes to food supply instability. When the organic matter in soil is reduced as a result of erosion, the soil's water-retention capacity declines so that the land becomes more vulnerable to short-term dry spells. A study by the U.S. Center for Environmental Assessment Services showed that eroded soils with a yield 30 percent less than a non-eroded control plot also had a yield that was four times more variable. Too often, efforts to expand output by

extending cultivation onto marginal land increase harvest variability and global food insecurity.

Another source of world food insecurity is the dependence of the entire world on North America for food supplies. This unhealthy dependence has both meteorological and political dimensions, since both the United States and Canada are affected by the same climatic cycles. The United States halted grain shipments to both the Soviet Union and Poland in the fall of 1975 because grain prices at home were rising too fast; Canada refused to license wheat exports in 1975 until it could more precisely determine the size of its harvest.

Stripped of its reserves, the international community can no longer be counted on to respond effectively to crop shortages in poor countries. During the fifties and the sixties, the story was quite different. Then, the United States intervened unilaterally with food-aid shipments wherever famine threatened. For example, after consecutive monsoon failures in India in 1965 and 1966, the United States shipped a fifth of its wheat crop to that country two years in a row to avert famine. In the 1970s, food scarcities and oscillating grain prices affected all countries, but the poorest ones suffered most. One of the hardest hit was Bangladesh. With two poor harvests, Bangladesh saw death rates climb sharply: an estimated 427,000 lives were lost in 1971/72, and another 330,000 in 1974/75. India too was hard hit during the seventies. After a weak monsoon and a poor harvest in 1972, the Indian Government discovered that the Soviet Union had tied up most of the world's exportable wheat supplies, leaving little for India to use. The increase in death rates above the previous year in the three poorest states of Uttar Pradesh, Bihar, and Orissa claimed an estimated 829,000 lives. This loss of life far exceeded the total combat fatalities in any war since World War II.

During the seventies, hunger also took a heavy toll in Africa, where a prolonged drought in the Sahel brought the deteriorating food situation into sharp focus. Senegal, Mauritania, Niger, Upper Volta, Chad, and Mali--all lost lives. No one knows exactly how many died of starvation and hunger-related disease. Further east in Africa, the ecological deterioration of Ethiopia's food system was also made all too apparent by a drought that claimed an estimated 200,000 lives and brought Haile Selassie's 47-year reign to an end. In Somalia, too, thousands died of severe malnutrition and disease in 1975; many of them perished after they reached relief camps.

Although grain stocks were partially rebuilt in the late seventies after these calamities occurred in Africa and Asia, the global supply-demand balance remains delicate, as the sensitivity of commodity prices to weather reports indicates. Now, a poor harvest in a major producing country can set off a wave of global inflation. In poor countries, where rising food prices can push death rates upward, reduced harvests can have a demographic, as well as an economic, impact.

Following the grim experiences of the early seventies, the United Nations convened a World Food Conference in Rome in November 1974. In addition to the general agreement on a greater effort to expand world food output, there was also agreement on the need to create an international food reserve. After years of negotiation, little progress has been made. In late 1980 the United States passed the Food Security Act which finally establishes a modest food reserve with an initial input of four million tons to assist countries experiencing severe food shortages. This aside, the international community has made little progress in building an effective international food reserve.

Land Productivity Trends

In a world where 70 million new residents are added each year and where little fertile land awaits the plow, land productivity is the key to the food prospect. From the beginning of agriculture until World War II productivity edged upward only slowly, sometimes remaining static for long stretches. Rice yields in nineteenth century Japan, for instance, were only marginally higher than those obtained during the fourteenth century. U.S. corn yields during the 1930s were no higher than those during the 1860s, the first decade for which reliable yields estimates are available.

Following World War II, however, crop yields began to rise in a sustained, systematic fashion in virtually every industrial country. During the sixties, the introduction of the fertilizer-responsive varieties of wheat and rice enabled many Third World countries to raise food output per hectare too. Between mid-century and the early seventies the steady rise in cereal yield per hectare was one of the most predictable trends in the world economy, increasing at an average of 2.2 percent annually. Since 1970, however, the rate has fallen to 1.5 percent per year (see Table 4).

Numerous factors appear responsible for a slower rate of yield increase. In the great majority of situations, the new cropland being brought under the plow is of lower quality than the land already in use. Often the marginal land added replaces the prime land that is continu-

Table 4. World Production, Harvested Area, and Yield of Cereals, 1950–80

Year	*Production*	*Area*	*Yield*
	(million metric tons)	(million hectares)	(metric tons per hectare)
1950	631	601	1.05
1960	863	682	1.26
1970	1137	704	1.62
1980	1432	758	1.89

Source: U.S. Department of Agriculture.

ally being withdrawn for non-farm uses, leading to a reduction in land quality that is not measured in data on overall cropland area. Also sapping farmland productivity is the reduction of fallow area in dryland farming regions. As world wheat prices rose between 1969 and 1974, U.S. summer fallow land dropped from 17 million hectares to 13 million. The U.S. Agricultural Attache in Moscow reported a strikingly similar reduction in fallow land in the Soviet Union from 17 million hectares to 12 million after the massive crop shortfall and heavy imports of 1972.

In tropical and subtropical regions, where fallowing has evolved as a method of restoring fertility, mounting population pressures are forcing shifting cultivators to shorten rotation cycles and thus to undermine the land's productivity. For example, in Nigeria, where farming has been expanded onto marginal land and fallow cycles shortened, cereal yields have been falling since the early sixties. A World Bank study of Nigeria reports that "fallow periods under shifting cultivation have become too short to restore fertility in some areas." In some locales, the original cropping cycle of 10 to 15 years has already been reduced to five.

While the shortening of fallow cycles is reducing land productivity in some countries, soil erosion is reducing it in others. One of the big unknowns facing agricultural analysts is how rapidly excessive soil erosion will reduce land productivity. If this erosion continues in the U.S. Corn Belt, the U.S. Department of Agriculture estimates that "potential corn and soybean yields would probably be reduced by 15 to 30 percent on some soils by the year 2030." A study of the erosion of Piedmont soils in Georgia showed a six-inch loss of topsoil reducing average yields 41 percent. A similar degree of erosion in West Tennessee led to a 42 percent drop in corn yields.

Some agricultural scientists believe that inherent biological constraints will eventually restrict crop yield per hectare. One analyst of this issue, Louis Thompson of Iowa State University, has plotted the average corn yields recorded on several experimental stations in Iowa from 1958 to 1972, as well as those achieved by the state's farmers. In the late fifties, the gap between average yields on experimental plots and those on working farms was wide, but by the early seventies it had virtually disappeared. In effect, the backlog of new technology has been largely used up, and Iowa farmers are literally looking over the shoulders of the agricultural scientists working the experimental plots.

While enormous opportunities for raising cropland productivity exist in some countries, the outlook for dramatic worldwide increases appears less hopeful now than it was at mid-century. Soil erosion is lowering the inherent fertility of perhaps one-fifth of the world's cropland, while the backlog of new agricultural technologies in the agriculturally advanced countries is dwindling. Together, these two factors cast a

formidable shadow over the prospect of a continuing rapid rise in land productivity.

Substituting Fertilizer for Land

When German chemist Justus von Liebig discovered in the 1840s that all the nutrients that crops remove from the soil could be replaced, he set the stage for the extensive substitution of chemical fertilizer for land as the frontiers closed. Since 1950, the expanding use of chemical fertilizer has been the principal source of growth in world food output. Increasing the use of irrigation, pesticides, and improved seeds has contributed to that growth, but without chemical fertilizer world food output would likely fall by at least one-third.

The three basic plant nutrients that can readily be supplied to the soil as chemical fertilizers--nitrogen, phosphorus, and potassium--all require substantial amounts of energy to mine or synthesize and to transport. Particularly large amounts of energy are required to synthesize atmospheric nitrogen into stable compounds that can be used for fertilizer. In 1950, the world's farmers applied some 14 million tons of chemical fertilizer to the soil. By 1980, they were using 113 million tons--an eightfold increase over a three-decade span (see Figure 1). At mid-century, worldwide fertilizer use averaged 5.6 kilograms per person, but by 1980, it had climbed to 25.6.

Crop yields increase predictably with each increment of chemical fertilizer--rapidly at first, then more slowly until they eventually level off. Understanding this fertilizer-response curve is key to

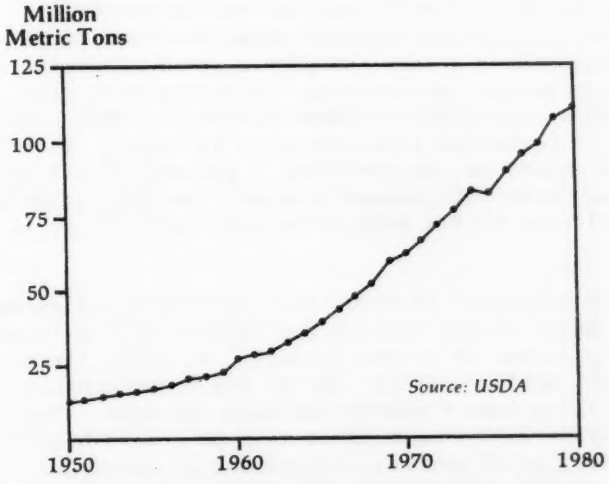

Figure 1. World Fertilizer Consumption, 1950-80

understanding future food production prospects. Where fertilizer use is intensive, the response is already diminishing. In the Netherlands, Japan, the U.S. Corn Belt or elsewhere, when the use of chemical fertilizer is close to the saturation point, further increases simply will not appreciably increase yields. In such countries as India and Argentina, where fertilizer application rates are still low, the response to additional applications of fertilizer is high.

While future fertilizer requirements cannot be projected precisely, the amount of fertilizer required per capita to satisfy future food needs is certain to increase if population growth continues. As long as the cropland per person continues to shrink, the amount of fertilizer needed per person will rise. As a result, food production will become progressively more energy-intensive, claiming a growing share of the world's scarce energy resources by the year 2000.

The Grain-Livestock Economy

Although most of the world's 1.4 billion ton annual grain harvest is consumed directly, a substantial share is consumed indirectly as livestock products. In the absence of religious restrictions on diet, the consumption of meat, milk, and eggs invariably rises with income. This whetted appetite for animal protein, in turn, translates into increases in grain fed to livestock. When world grain supplies are short, the competition between people and livestock for grain becomes acute.

Although corn and some other grains are used largely as feed and others, such as wheat, primarily as food, all grains can be used for either purpose. As of 1979, annual grain use per capita ranged from roughly 160 kilograms in countries such as India and Kenya to just over 800 kilograms in the United States and the Soviet Union. The lower end is determined by minimal survival requirements. If consumption drops below 160 kilograms per year (roughly a pound of grain per day), malnutrition becomes severe and mortality rates begin to climb. In the United States, Canada, and other affluent countries, some three-fourths of the grain used is converted into livestock products. In India, China, and similar countries, no more than 3 percent of the available grain supply is converted into animal protein. In Japan, the United Kingdom, and Brazil--the middle ground--roughly half the grain used is fed to livestock.

Despite rising affluence in industrial societies and among Third World elites, the share of the world grain harvest fed to livestock has remained remarkably stable in recent decades. In 1960, livestock and poultry consumed 255 million metric tons of grain, or roughly 31 percent of the 835 million tons consumed for food and feed. The overall numbers were larger in 1979--450 million tons of a 1.43 billion ton total--but the share, at 32 percent, was virtually unchanged. The balance held because the increases in the grain used for feed were offset

by faster population growth in the poorer countries which increased that used for food.

While the amount of meat consumed is determined by income, the type of meat is influenced by population/land ratios. Those industrial countries that consume mostly beef have extensive grazing land--the United States, Canada, the Soviet Union, Australia, Argentina, and Brazil. In industrial countries that are more densely populated, such as those in both Western and Eastern Europe, pork dominates. Pork is also the dominant red meat in east Asian countries such as China and Japan (see Table 5). The efficiency with which grain is converted into meat varies widely by country. For example, although per capita grain use is just over 800 kilograms (food and feed) in both the United States and the Soviet Union, those 800 kilograms provide each American consumer with 111 kilograms of meat and each Soviet only 51 kilograms. The far better managed American farms get more than twice as much meat as Soviet farms do from a ton of grain.

One way of increasing meat production when feed supplies are tight is to switch to those animals such as chicken that convert grain into meat most efficiently. This trend, now worldwide, helps explain why poultry production has outstripped that of other types of meat over the past decade or so. In the United States, where chicken was a Sunday dinner treat less than a generation ago, consumption has now climbed above 26 kilograms per person per year. Nevertheless, in spite of efforts to raise the efficiency of grain conversion into livestock products, competition between people and livestock for scarce grain supplies seems certain to intensify as pressures on the world's agricultural resource base increase.

The growing demand for animal protein has generated an enormous demand for soybean meal for livestock rations. Soybeans are an ideal

Table 5 Meat Consumption Per Capita in Selected Countries, 1978

Country	*Beef & Veal*	*Pork*	*Mutton, Lamb & Goat*	*Poultry*	*Total*
			(kilograms)		
USA	56	28	1	26	111
France	32	34	4	16	86
Poland	19	48	1	11	79
USSR	25	14	4	8	51
Brazil	18	7	—	7	32
Japan	5	12	2	10	29
China	2	15	1	3	21
Egypt	4	—	1	3	8
Nigeria	3	—	1	2	6
India	0.3	0.1	0.5	0.2	1.1

Source: U.S. Department of Agriculture, Food and Agriculture Organization, and author's estimates.

protein complement to cereals in livestock and poultry rations. Since 1950, the world soybean harvest has multiplied fivefold, climbing from 18 million tons to 85 million. Growth has been particularly rapid since 1970, when the world fish catch leveled off, and 1980: the world soybean harvest doubled from 42 million tons to 85 million tons. In the United States, where the soybean was introduced from China, acreage in soybeans now rivals that in corn and wheat. While the Chinese harvest of nine million tons is used almost entirely for food, much of it as bean curd (tofu), most of the far larger U.S. and Brazilian soybean crops are used for feed, either domestically or when shipped abroad. An estimated two-thirds of the world harvest is now consumed as soybean meal, principally by livestock.

What do these dietary patterns and trends say about the world food supply-demand equation? First, a vast potential for increased grain use for livestock feed exists in low-income countries if purchasing power permits. Second, in the event of a dire world food emergency, millions of tons of grain and soybeans could be diverted from feed to food use. Indeed, diverting only a quarter of the world soybean harvest from feed use to direct human consumption would provide five kilograms per year of a high protein food for everyone in the world. The key here, of course, is making the shift before food prices have risen high enough to push up mortality rates among the world's poor--something the market is unlikely to do on its own.

The New Food-Fuel Competition

As the eighties begin, the longstanding competition between food and feed is expanding to include fuel. In the past, the energy sector has supported the food sector, providing fuel for fertilizer and pesticide production, tillage, harvesting, crop drying, and numerous other farm-related processes. With energy subsidizing agriculture, the earth's population-sustaining capacity increased dramatically. But now, as the shortage of liquid fuels grows, energy producers are beginning to compete with food producers for limited agricultural resources.

In the rush to develop indigenous liquid fuels to replace imported oil, alcohol distilled from farm commodities has emerged as a short-run alternative. Several countries have already launched agriculturally based alcohol-fuel programs. Brazil, the United States, and the Philippines have major programs to convert agricultural commodities into alcohol for use as an automotive fuel, while Australia, New Zealand, and South Africa have programs either in operation or on the drawing board. In 1980, Brazil devoted nearly one million hectares of cropland to the production of sugarcane for automotive fuel; the United States used some 80,000 hectares to produce grain that was converted into alcohol fuel; and the Philippines started marketing "alcogas" made from sugarcane. For countries buffeted by soaring oil prices and fearful of supply disruptions, the prospect of an indigenous substitute for some of

the imported oil is reassuring, but it means that automobiles now compete with people and livestock for the harvest.

Until recently, the claims of the poor and the rich on the earth's agricultural resources have not diverged by more than a factor of five, the difference between an affluent diet rich in livestock products and a grain-based subsistence diet. If energy crops are figured in, however, the ratio could increase dramatically since an automobile run on alcohol requires far more grain than a person does. Satisfying the annual food needs of a typical Third World consumer requires roughly one quarter of an acre of cropland, whereas the more affluent diet in an industrial society requires nearly an acre. By contrast, a typical American car fueled entirely by ethanol would require processing over seven tons of grain per year--the output from nine acres of average grain land. In Western Europe, where cars are more fuel-efficient and are driven less, the typical automobile could be run on a little over three tons of grain per year. These numbers are hypothetical, because no country except Brazil is running automobiles exclusively on alcohol and because grain is by no means the only commodity from which alcohol can be made. Nonetheless, they indicate how quickly alcohol fuel programs could absorb vast amounts of grain.

Providing gasohol in a 10 percent alcohol blend for the typical U.S. car would each year require 1,460 pounds of grain, or slightly less grain than the average American annually consumes directly and indirectly as food. Accordingly, the cropland requirements of an American car owner who switches to grain-based gasohol would nearly double--rising from .9 to 1.7 acres. To the degree that the protein-rich by-product of the distillation process, distiller's dried grain, can be used successfully as livestock feed, this land requirement could be reduced. But if liquid fuel is used to produce and distill the grain, more land will be required to produce sufficient net amounts of liquid fuel. In the second case, headway toward reducing oil imports will be made two steps forward, one back. Brazilian agricultural officials argue that energy crops will be produced in addition to rather than instead of food crops. In fact, though, energy crops compete not only for land but also for agricultural investment capital, water, fertilizer, farm-management skills, farm-to-market roads, agricultural credit, and technical advisory services. Only in a centrally planned economy where all agricultural inputs are carefully controlled and clearly tagged for the production of either food or energy, could a major energy-crops program be launched without siphoning resources away from food production.

For food-exporting countries, the immediate appeal of converting exportable food surpluses into alcohol fuel is undeniable. But in a world that has little if any excess food-production capacity, channelling foodstuffs into fuel production will inevitably drive food prices

upward. For the several hundred million people who are already spending most of their meager incomes on food, rising food prices will further narrow the thin margin of survival.

The Food Price Prospect

As the demand for food continues to press against the supply, inevitably real food prices will rise. The question no longer seems to be whether they will rise but how much and when. Since mid-century the growth in world grain production has unmistakably lost momentum. Expanding at well over 3 percent per year during the fifties, growth fell to just over 2 percent annually during the seventies.

In efforts to eliminate hunger, this loss of momentum is aggravated by the heavily skewed distribution of income both within and among countries. Average incomes among the wealthier one-fifth of humanity are easily 20 times those of the poorest one-fifth. Similar ratios exist between the wealthiest and poorest fifths within societies where wealth is concentrated in a few hands, such as Iraq, Senegal, Brazil, Ecuador, and Mexico. Without effective efforts to redistribute income, meaningful progress in the eradication of hunger is unlikely.

The worldwide loss of agricultural momentum is serious in itself. But more serious are the gathering forces behind this loss. It is becoming ever more difficult to expand the cropland base, and soil erosion's toll on productivity is continuing unabated. Returns on the use of chemical fertilizer at the margin are also diminishing. Each of these forces promises to become an even stronger drag on the growth of food production during the eighties.

It is tempting to look to science and technology for help. But at the moment new agricultural technolgoies provide only small comfort. Hopes run high for increasing the photosynthetic efficiency of major crops and for developing cereals that can fix nitrogen. But these advances represent major feats of biological engineering, feats that cannot be taken for granted. If commercial nitrogen-fixing cereals become a reality, they will reduce energy requirements in agriculture but not necessarily increase output. Beyond these two possibilities there does not appear to be anything on the technological drawing board that could lead to quantum jumps in world food output. We cannot expect gains such as those made possible in postwar agriculture by the use of chemical fertilizer, improved seeds and irrigation.

Perhaps more than anything else, the price of food will be influenced by oil prices. After the price of oil began its rapid climb in late 1973, it left the comparatively stable price of food far behind. But there are signs that food prices might begin a long-term climb as well. Even as the price of liquid fuels required for farming rises,

agriculture is being seen by more and more governments of oil-importing countries as a source of liquid fuels. At the same time the sharp shift in the terms of trade between oil and grain tempts populous, oil-exporting countries that are having problems in agriculture to import more food. For countries such as the Soviet Union, Nigeria, Mexico, and China, the terms of exchange between oil and grain are exceedingly attractive, and they are rapidly expanding their food imports as the eighties begin. This extraordinary leverage in the world grain market is driving food prices upward far more rapidly than was possible when a barrel of oil and a bushel of wheat had the same value. In effect, the price of oil is gradually pulling the price of food upward in its wake.

This new relationship between the food and energy sectors makes food projections more complicated than ever before. The principal cushion now remaining in the world food economy is the grain that is fed to livestock. This grain could easily be made available for human consumption in times of shortage, though so far it has been diverted from livestock only when the price climbs to a level that induces widespread starvation. Just as the seventies dramatically underscored the new energy realities, the eighties promise to do the same for food. Indeed, rising food prices may become a more or less permanent feature of the economic landscape in the years ahead. Few, if any, economic indicators are as politically sensitive as food prices.

[Extracted from Chapter 5 of Building A Sustainable Society, W. W. Norton and Co., New York and London. Copyright© 1981 by Worldwatch Institute.]

Editorial Note: Since this text was published in 1981, some of the trends discussed have changed direction. As of mid-1983, the following shifts may be noted: world grain harvests have increased, and international prices have decreased. U.S. grain farmers are again taking significant acreage out of production. Western Europe has continued to reduce its dependence on imported grain. Oil prices have weakened, and with them other energy prices; the incentive to substitute grain alcohol for oil as an energy source in the United States has diminished somewhat, although sharp increases in the price of gasoline in Brazil have boosted the demand for alcohol from sugarcane. It is the author's view that such shifts in direction are to be expected in phenomena dependent on weather and on complex combinations of economic variables. This does not, however, reduce the importance of the longer term trends in resource availability involving topsoil, land quality and population numbers. The real costs of energy are still several times their pre-1973 levels, and in any case the volume of petroleum left underground is certain to have some overall limit and to become more costly to extract as time passes.

Global Food Security — A Manageable Challenge

Clifford W. Lewis

[This article takes a more optimistic view of the prospects for food security than does the preceding one. The 100-year trend of decreasing real food costs is expected to continue, bolstered by improvements in the international grain markets. Reduction of malnutrition, often a problem in domestic income distribution rather than one of national food shortage, can be accomplished by targeted feeding programs.]

Current opinions about food security have been strongly influenced by the "world food crisis" of a decade ago. In 1972-74, poor harvests in several large countries coincided with changes in long standing agricultural, trade, and monetary policies, resulting in the rapid drawdown of grain stocks. On every continent, governments scrambled to control supplies. In the process international prices rose to record levels. As a result, it was commonly argued that the era of cheap food and abundant supplies was over. Many suggested that widespread starvation was imminent and the concept of "triage" was seriously debated. Influenced by these dramatic events, many authorities have since held that global food security can only be achieved by new initiatives to regulate trade, create buffer stocks and control domestic food allocation.

But the dislocation caused by the panic prices of the early 1970s proved to be shortlived, and was followed by a period of rapid adjustment. Within a few years the real cost of food imports had dropped to levels below those of the 1960s--without resort to new controls or reserves. Trade in grain continued to expand rapidly, more than doubling in volume in the decade of the 1970s, making access to supplies increasingly easy. Neverthe-

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less, concerns about the adequacy of future food supplies have continued to figure in international discussions at the Food and Agriculture Organization and World Food Council as well as in numerous published predictions of imminent food crises. This paper addresses some of the most common assertions made by those who remain pessimistic about food security, particularly in developing countries.

Trends in World Grain Prices, Supply, and Trade

This paper's statistical analysis relies on data about grain production, consumption, and international trade, with the definition of grains including wheat, rice, coarse grains, soybeans and associated byproducts. The reason for focusing on grains rather than all foods--which would be preferable--is the lack of reliable data about food other than grains. Further, grains are by far the most important foods in international trade and for basic nutrition, especially for the poor. (In some developing countries well over half of all food calories are provided by grains.) But it should be emphasized that food security is not synonymous with security in foodgrains, and that foods other than grains are increasingly important in international trade and remain essential components of diets.

Despite the weakness of data about global food trends it is clear that global grain production has grown at a generally increasing rate since the early decades of the 19th century and has consistently outstripped increases in global population. As a result, the price of food has declined steadily in real terms, with temporary interruptions when peace has not prevailed (see Table 1).

Table 1: WHEAT PRICES, 1890-1981

(1967 US dollars per bushel)

1890	3.09
1900	2.44
1910	3.01
1920	3.08
1930	2.02
1940	2.15
1950	2.72
1960	2.10
1970	1.34
1980	1.40
1982	1.10

Source: USDA series for Kansas City #3 Wheat, adjusted by US wholesale price index.

As global grain output has grown, it has become proportionally less variable from year to year: according to regional data on production since the early 1960s, the absolute size of the annual variations has increased, but so has the production base. Although the disturbances in 1972-74 caused fears of rising supply instability, the overall record shows that the coefficient of variation was smaller in the 1970s than in the 1960s. (The coefficient of variation is the average difference from the mean divided by the mean.) Most global supply variations in recent decades came from the US (largely associated with changes in farm support programs) and USSR (largely caused by variations in yields). The US and the USSR together supply about 32 percent of the world's grain.

These trends in grain output have occurred in industrialized and developing countries alike. Since 1950, developing countries have increased their grain production more rapidly than industrialized countries, though their population growth rates have been such that their per capita supplies of grain have risen only slightly (see Table 2).

Table 2: GROWTH OF GRAIN PRODUCTION AND POPULATION, 1960-80

(Average annual percentage change)

	Cereal Production		Population		Average Self-Sufficiency (Percent)	
	1960-70	1971-80	1960-70	1971-80	1960-63	1979-82
USSR and Eastern Europe	3.7	0.6	1.0	0.9	100	83
Industrialized Market Economies	3.7	3.0	1.0	0.7	106	129
Developing Countries a/	3.2	3.2	2.5	2.4	96	89
WORLD b/	3.5	2.6	2.0	1.7	100	100

a/ Excluding China
b/ Including China

Sources: USDA and World Bank.

As grain supply has risen and become more stable, international trade in grain has expanded. The proportion of the total grain supply crossing national borders rose from 6 percent in 1950 to about 16 percent in 1981. This growth in trade has been associated with changing patterns of cereal consumption in certain importing countries which have become increasingly dependent on world markets. Most notably, in the early 1970s the USSR and Eastern Europe, which has been net exporters in the early 1960s, became dependent on imports. This development reflec-

ted a massive increase in feedgrain consumption by livestock and, increasingly, production problems.

Changes in World Grain Markets in the 1970s

Expanding global markets have made it easier for countries to sell agricultural exports or buy imported grain to make up for poor local harvests. Reliance on international food markets as a means of stabilizing domestic supplies has seemed paradoxical to many governments, since these markets are so widely perceived as unstable. Yet, even in 1973 when export supplies were tight and prices high, the main bottleneck to grain purchases by poor countries was logistical problems rather than price or availability of supplies.

From the standpoint of an individual country, world grain markets have provided an extremely effective reserve when domestic supplies are tight. This reserve has three parts. First, are aggregate trade flows: these have doubled in volume from some 120 million tons in 1970/71 to over 260 million tons in 1980/81. Second, are non-governmental stocks, currently at about 80 million tons, which backstop trade flows and are available for delivery within 2-3 months. Third, and most important, is the 650 million tons of grain annually fed to livestock, a substantial portion of which can be diverted to meet human needs. This diversion is what happened in 1973/74; it happened again in 1975/76, when world grain harvests were dramatically below trend (by about 66 million tons), but grain markets remained calm.

The reasons why price instability and the removal of controls have not dampened imports by developing countries--or production by exporters--range from basic changes in the global monetary system to more mundane technical improvements in grain trading. Some of the more important new factors that make the global grain trade more reliable are the following.

Sources of Supply and Competition. The increase in demand for grain imports has been met by a growing number of suppliers in increasingly competitive markets. Important new production areas have been opened up in Southern Hemisphere developing countries, which arrive in world markets well before the North American harvest, thus reducing the need for global stocks. Annual grain exports from South America--mainly Argentina and Brazil--have risen from 10 million tons in the early 1960s to about 40 million tons today. Production increases of a similar size have been achieved in the European Community. While the US has remained the major supplier of grains it has not exercised monopoly power over the world market. Alternative sources of supply--particularly for rice and wheat where the US market share is smaller than in other grains--give importers substantial flexibility.

Better Information. Improved information systems including remote sensing, weather forecasting and ground surveys have permitted major breakthroughs in the ability to monitor upcoming harvests throughout the world. This has enabled the world market to know in advance of exceptional crop shortfalls and possible import requirements. As a consequence, major producing countries such as the USSR can no longer surprise the market. Substantial improvements have also been made in the mechanisms through which the USSR and other centrally planned economies make purchases, and information exchanges between them and suppliers have now been regularized to minimize the risks from unexpected decisions.

Integration of the Global Market. With improved telecommunications and information gathering, the organized grain markets now provide an almost instantaneous and generally accurate reflection of the changing judgments of buyers and sellers throughout the world. Almost all international trade and the great bulk of marketed production is priced on the basis of changes in a handful of carefully watched markets. Exporters throughout the world sell at roughly the same world market price, even when domestic farmers are paid a different price (as they are in the EEC). And government-to-government sales agreements--increasingly important in trade--specify quantity ranges, leaving prices to the market. Less than 10 percent of current world trade takes place on non-market terms.

Growth of Futures Trading. The organized grain futures market grew almost twentyfold in the 1970s--the value of total annual transactions now approaches $300 billion--and now provides an immense base for absorbing incremental trading activity that would previously have been disruptive. Even more important, the large volume of trading permits reliable "hedging," through which trading partners can lock in acceptable prices for future cash transactions. This also makes it possible for nongovernmental decision makers to hold carryover stocks profitably, reducing the argument for special buffer stocks. Since they reflect current and expected supply and demand levels, the futures markets give clear signals as to when grain should be released into the market or alternatively held in stock. In late 1980, for example, when prices rose more rapidly than in 1972, only moderate amounts were released from stocks, which in the aggregate remained sufficient to meet subsequent demand. This was in striking contrast to experience in 1972, when government decisions caused excessive liquidation of stocks.

New "Safety Net" for Poor Countries. Agreements reached by the late 1970s help to assure that poor developing countries will be able to buy food in the event of local crop shortfalls or high import prices. First, a binding Food Aid Convention under the international wheat agreement, signed by all the major exporters and importers

(including USSR), guarantees a minimum of 7.6 million tons of concessional deliveries each year. This is double the amount of concessional food aid that actually arrived in 1974, and is larger than all current net imports of food by low income countries (excluding China). Second, the IMF Compensatory Financing Facility has been expanded to include concessional medium-term credit for cereal imports. Loans from the Facility are made for 5 years (with 2 years' grace) at an interest rate of 7 percent; they are not subject to IMF conditions about the borrower's domestic policies. A country cannot draw more from the Facility than 100 percent of its IMF quota, but the maximum is not affected by its drawings on other IMF facilities, and in practice this drawing limit should not prove constraining. A review by IMF staff of developing countries' experience in 1960-80 showed no instance where an increased bill for food imports exceeded a country's IMF quota. In any case, it has recently been agreed that all IMF country quotas will be raised by over 50 percent.

Food Imports by Developing Countries

There is a great difference in the food-trade position of low-income and middle-income developing countries. While the latter have increased imports in line with rising incomes, the former have not, partly because their incomes have grown less rapidly and from a far lower base.

Among low-income countries, too, degrees of dependence on imported food differ widely. Through raising their domestic production, South Asian countries have been able to reduce their dependence on imports to feed the urban poor. In India, increased surpluses in the Northwest displaced imported foodstuffs in the major urban areas; as a result, most of the staples distributed through the public rationing system are no longer imported. Similar progress has been made in Bangladesh and Pakistan where steadily increased surpluses in a few districts have either reduced dependence on imported basic food in the cities (Bangladesh) or increased exports (Pakistan). These three countries together represent about 30 percent of the total population of low-income countries, or 80 percent excluding China. As discussed below, the trading position of low-income Africa is very different.

As Table 3 shows, in the middle-income country groups, where cereal imports grew most rapidly, per capita food production also grew. In meeting their citizens' "affluence requirements," the middle-income countries had by the late 1970s passed the industrialized countries as the largest importers of grains. Higher incomes, particularly in urban areas, led to shifts in the kinds of commodities being consumed; wheat became more important as did other higher value foods such as meats and fresh vegetables.

Table 3: FOOD IMPORTS AND PRODUCTION, 1960-1981

	Average Annual Growth of Cereal (Percent)			
	Imports		Production	
	1960-70	1970-80	1960-70	1970-80
Middle income oil exporters	5	13	3	3
Middle income oil importers	7	9	4	4
Low income 1/	-1	-4	3	3
Asia 1/	-1	-7	2.7	3.2
Africa	9	10	3.4	1.1

1/ Excluding China

Sources: USDA and GATT.

Developments in Sub-Saharan African countries are in striking contrast to the general trends. Unlike other aspects of the current world food situation, the scarcity of food in these countries is approaching the proportions of a crisis. Although the share of total foreign exchange that they devote to commercial food imports has declined somewhat over the past two decades--and each individual country runs a substantial surplus on its agricultural trade--their volume of food imports has risen in relation to domestic production. Because domestic supplies of food have grown so slowly, the rapidly growing urban areas in these countries have had to rely increasingly on imported staples; currently about 80 percent of all cereals consumed in urban areas is imported (a higher proportion than for the middle income countries as a group).

Food Imports and the Balance of Payments. For the great majority of developing countries, imports of food are not a major foreign exchange burden. As always, some countries have fared much worse than the average. When their own harvests have been poor, certain low income countries have had to forego planned imports of various kinds in order to buy food. Making these purchases on commercial terms has sometimes been very costly: certain countries have had to devote, albeit for only one year, almost half of their annual export earnings to buy food. But for developing countries as a group, food imports have constituted a relatively small and declining proportion of the import bill over the past two decades (Table 4).

The increased pressure on balances of payments--a serious problem for many relatively affluent food importers--has come not from food

Table 4: FOOD AS A PROPORTION OF ALL IMPORTS

	1960-62	1979-81
Middle-income oil exporters	19	14
Middle-income oil importers	14	10
Low-income	22	17

Sources: USDA and GATT.

but from oil, whose real cost increased sixfold while that of grains declined, and from debt servicing and other imports (Table 5). For example, in the late 1960s, cereal imports cost the low-income countries over twice as much as oil imports; in the middle-income countries, the costs of oil imports and cereal imports were comparable. By 1979 the cost of petroleum imports rose to double the cost of cereal imports in low-income countries, and to seven times this cost in middle-income countries. Over the 1970s, the foreign exchange burden of food imports also grew less rapidly than the earnings from agricultural exports, so that in agricultural trade, most of the developing countries were in surplus by the end of the decade.

Table 5: BURDEN OF CEREAL IMPORTS VERSUS OIL IMPORTS, 1969-79

(million US dollars)

	Low-Income Countries			Middle-Income Countries		
Year	Cereal Imports a/	Oil Imports	Agricultural Exports	Cereal Imports a/	Oil Imports	Agricultural Exports
1969	717	167	3,021	1,249	1,918	10,170
1970	748	261	3,274	1,272	2,156	11,177
1971	602	361	3,243	1,490	3,025	11,327
1972	496	379	3,602	1,437	3,420	13,846
1973	1,346	558	4,303	2.806	5,826	18,971
1974	2,176	1,872	5,134	4,590	18,316	24,207
1975	2,934	2.037	5,430	3,902	18,120	24,436
1976	2,353	2,172	6,338	3,703	22,744	28,527
1977	1,032	2,296	7,335	3,214	25,349	35,700
1978	1,163	2,493	6,754	4,168	26,900	37,071
1979	1,453	3,288	7,990	5,540	37,439	41,546

a/ Including food aid valued at commercial terms

Sources: FAO and World Bank.

There is more scope for reducing expenditures on food imports to cope with a shortage of foreign exchange than there is, in the short run, for reducing expenditures on energy imports or foreign debt. First, the rise in developing countries' food imports--except in Sub-Saharan Africa--has been associated with increases in per capita income rather than with declines in domestic production.

Second, most individual developing countries have substantial scope for changing to cheaper imported foods when prices are high or foreign exchange is scarce. Almost all of the middle-income countries spend very much more foreign exchange on foods consumed primarily by high-income groups than on foods eaten by the poor. In the late 1970s, foodgrains accounted for less than a third of the total food import bill of middle-income countries. The same pattern has more recently emerged for many low-income countries in Sub-Saharan Africa, where a high proportion of total foodgrain imports is financed through food aid (from 30-60 percent for individual countries).

When considering the effects of reducing food imports when foreign exchange is tight, it should be remembered that the regular food imports of the poorest developing countries have little impact on the diets of the most needy, 90 percent of whom live in relatively isolated rural areas. The poor lack purchasing power to pay for imports; and there are generally immense logistical difficulties in distributing imported food on a large scale in remote areas. The lack of rural purchasing power--and resulting food insecurity--is a byproduct of low farm production; food imports tend mainly to exacerbate the problems of rural-urban differences and of insufficient rural employment.

Third, it is also worth noting that the cost of food imports depends to a large extent on the skill of the purchaser. Recent changes in world markets have helped to widen the gap between the more efficient traders and those others that have followed inappropriate import practices. Developing countries have not generally taken advantage of mechanisms such as basis trading (negotiating each element of the delivered cost on the most advantageous terms), which can help lower the cost of food imports. The cost of retaining systems appropriate in the 1960s has proven high. Judging from country case studies--which have been confirmed by trade sources--developing countries as a group could save up to $1 billion in foreign exchange each year, out of their total commercial grain imports of about $8 billion. The sources of potential savings include freight and handling; improving purchasing arrangements, including timing; the type and grade specification of the food bought, and its point of origin; financing and insurance; market intelligence; and regularized and open trading procedures. That the potential savings are real is indicated by the fact that some countries (e.g., China, Chile and Colombia) in tight market situations appear to pay prices almost as low as the most efficient traders--commercial importers in industrialized countries.

The Incidence of Hunger and Small Farmer Production

Data on national food supplies or changes in world grain markets tell little about trends in the food consumption of the households in a nation or the incidence of hunger. A measure of the most extreme form of hunger is given by available statistics on mortality rates among children, who are more vulnerable than adults to inadequate food consumption. From the declines in child mortality rates and increases in life expectancy in all groups of countries (see Table 6), one may infer that the incidence of life-threatening hunger has declined substantially in the last two decades. Along with more secure supplies of food, better water supplies and health care have also helped to lengthen lives. Although the statistics show that hunger remains a problem in developing countries, where infant mortality rates are ten to thirty times higher than in industrialized countries, they also demonstrate that increased levels of food production at the national and global level, higher per capita incomes, and lower food prices have all helped to raise household food consumption and lowered the incidence of life-threatening malnutrition.

Table 6: INDIRECT INDICATORS OF NUTRITIONAL TRENDS, 1960-80

	Child death rates (age 1-4, per 1000)			Life Expectancy at Birth (years)		
	1960	1980	Fall (percent)	1960	1980	Rise (percent)
Low-income economies a/	28	12	57	42	57	36
Africa	38	27	30	39	46	18
Asia b/	21	11	48	48	58	21
Middle-income oil exporters	27	14	48	46	56	22
Middle-income oil importers	19	9	53	54	63	17
Industrial market economies	2	1	50	70	74	6
Non-market industrial economies	2	1	50	68	71	4

a/ Includes China
b/ Excludes China

Source: United Nations.

Critical to the progress made in reducing life-threatening malnutrition--and in assuring that food imports did not increase enough to become unmanageable--were programs undertaken by the largest low-income developing countries to increase the productivity of small farmer agriculture. Investment in irrigation has been important in many South and Southeast Asian countries; in India private farmers have invested about

$15 billion in groundwater irrigation covering about 30 million hectares since 1960. And overall, developing country governments are currently spending more than $15 billion annually to improve irrigation. Development agencies have also stepped up their efforts to improve agriculture, particularly small farmer food production, throughout the developing world. For example, the World Bank alone has spent over $30 billion on rural development in the past decade which has benefited almost 30 million small farmers, and which will increase annual developing country cereal production by over 30 million tons. Progress has also been made by many countries in providing more adequate price incentives, better extension and more applied research on new technologies.

At the same time, improvements in nutrition and the prevention of serious consumption shortfalls have also depended on extra-market food distribution programs undertaken by governments concerned about those too poor to be able to purchase adequate food. In urban areas, where governmental administrative capacity is generally strongest and poor people are concentrated in smaller areas, it has proven possible to provide low-income households with non-market sources of food at preferential or concessionary prices. In Sri Lanka, Pakistan, Chile and elsewhere, such programs have proven effective in raising the nutritional status of the bottom 20 percent in urban districts. Although there are inevitably leakages of food to the less poor in such programs due to managerial problems, ambiguous means tests, or the desire of program participants to raise cash by selling their concessionary items in the open market, good administrative practices have in most cases kept those losses low. Recent studies show that programs like that run by India--which benefits almost 50 million people who would otherwise be malnourished--to be highly cost-effective.

Over the past decade, substantial progress has also been made in reducing the loss of life associated with famine. While developing countries have had to cope with sudden and acute declines in the access to food of communities and groups not usually at severe nutritional risk, the consequences of famines have been less devastating than at any previous time. Further, recent studies indicate that in recent years famines have more often been associated with general dislocations such as civil disorder (as in the Horn of Africa or Southeast Asia) than with production shortfalls alone.

Food Prospects

At least for the next two decades, the world's supply of food is unlikely to be less secure than in the past. The annual increase in food production required to meet projected population growth is 1.6 percent at a global level and 1.9 percent for the developing world. This is considerably less than the overall growth rate of 2.6 percent

a year achieved since the end of World War II. Real aggregate purchasing power in the 1980s is projected by the World Bank to increase by no more than 2 percent per capita in industrialized countries, though at a higher rate in middle-income countries and a lower one in low-income countries. If historical relationships between income changes and food consumption continue to apply, the total demand for grain should grow at no more than 2.6 percent during the 1980s--about the same rate as that of the last three decades. At a global level, even if per capita real income were to grow as rapidly as 4 percent a year through 1990--which is highly unlikely--the increase in demand for foodgrains would still not exceed 3.0 percent a year. The 1960s, a period of comparatively rapid income growth, saw foodgrain production grow by 3.5 percent a year.

Supplies. The technical capacity to produce the supply required to meet the projected demand for food and feeds in the rest of this century is clearly available:

--The additional land resources that could be used for food production appear sufficient for some time to come. According to the FAO report on Agriculture: Toward 2000, some 200 million hectares of arable land remain to be exploited. In the US alone, a recent survey by USDA has indicated that some 50 million hectares of currently unutilized land have a potential for grain production estimated at 200 million metric tons a year (provided proper incentives are present). Even greater potential exists in other countries including Argentina, Australia, Brazil, and Canada.

--In land-scarce developing countries there is much room for improving productivity. Bangladesh, for example, with superior climate, soil and a potential for water control, currently achieves less than half the cropping intensity of comparable areas in East Asia.

--Increased concerns have been expressed recently about the lack of new technology in prospect, especially in relation to grain production in Northern America. While there may be no spectacular innovations pending comparable with, say, hybrid maize or the short-strawed wheat, there is a steady increase in the potential of a variety of food crops. The fastest productivity growth recently has not been in grains but in other subsectors, especially livestock and vegetable production, for which demand has been rapidly increasing. Continuous improvements can also be expected in the efficiency with which feeds are used.

Trade. Since the potential for increased production varies by region with no relation to population density, international trade in

basic foodstuffs can be expected to grow. Trade in grains will probably expand readily, even though "bottlenecks" in handling may develop from time to time. However, because of the less favorable economic and monetary conditions facing countries with rapidly growing food imports, such as Mexico, Nigeria, Poland, and the USSR, overall trade is not likely to grow as rapidly as in the 1970s. China's food imports are not likely to grow rapidly so long as central authorities continue to restrict the movement of population into urban centers. World Bank projections indicate that in the low-income country group, the split between relatively self-sufficient South Asian countries and more import-dependent Sub-Saharan African countries will continue. Unless food production is materially increased in Sub-Saharan Africa, in both middle- and low-income countries, imports will continue rising in line with urban populations, whose growth is expected to moderate somewhat but remain high. However, the incremental imports of Sub-Saharan Africa will still remain modest in relation to both world supply and these countries' total food consumption, with 10-12 percent of their nutrition being imported as compared with 8-10 percent currently.

Price Prospects. Barring a political catastrophe that might result in a disruption of trade, market fundamentals suggest there will be no substantial long-lasting upward pressure on food prices over the next decade. While forecasting future commodity price movements is extremely difficult and subject to substantial margins of error, the most recent World Bank assessment (Table 7) concludes that cereal prices, measured in real terms, will increase only slightly in the 1980s, which would not exceed long-term historical trends. These forecasts also indicate that the prices of the primary commodities other than fuel which are exported by developing countries will continue rising more rapidly than those of their nonfuel commodity imports. This should help to alleviate adverse effects from the current low levels and slow recovery in real commodity prices for those developing countries that depend on primary commodity exports to pay for food imports.

Table 7: PRICES OF MAJOR CEREALS, 1975-90
(1981 US dollars per metric ton)

	1975	1980	1990	1990 Range
Rice	564	419	425	387 - 463
Wheat	282	184	190	171 - 207
Maize	186	121	142	128 - 155

Source: World Bank.

Food Consumption. The global price trends will not be reflected in all developing countries; nor do average increases in per capita income necessarily indicate improvements in the incomes of lower-

income groups. The prospects for food consumption by these groups depend upon what happens to their purchasing power.

The fact that recent declines of 5-10 percent in per capita income in some South American countries have not caused demonstrable shortfalls in food consumption suggests that short-term adjustments can be made by the majority of people in middle-income countries. But if these countries do not quickly recover their trend growth in incomes there are real risks that food consumption by the more vulnerable groups would be adversely affected, with potentially serious nutritional and political repercussions.

In the low-income countries, and low-income areas of middle-income ones, food consumption prospects are not easily summarized. When households who are undernourished and vulnerable acquire more purchasing power, aggregate demand for foods rises. For major improvements in nutrition to occur, increases in demand should come largely from farming areas where markets are not now well developed and where supply increases have been constrained by the lack of demand. The production increases needed to meet such an increased demand over a 10 year period would be manageable, in light of World Bank project experience, at an estimated 15-20 percent; this would be in line with the actual increases achieved in comparably endowed, but less demand-constrained, districts. All of which is to say that in rural areas, the problem of food consumption is inexorably linked to that of food production, and that nutritional improvements will be based on higher local output.

Meeting the needs of those currently suffering from life-threatening malnutrition would not impose any strain on global food supplies. World Bank studies estimate that only about 5 million additional tons of foodgrains a year on a global basis would be needed to satisfy all the currently unmet nutritional requirements. This is less than current levels of food aid, and about 0.3 percent of global supply. It represents no more than a 5 percent increase in the domestic consumption of any one country. This is not to suggest that the requirement needs to be met by an internal redistribution of consumption, but rather to emphasize that the problem of inadequate nutrition is not one of inadequate supply potential.

Natural Shocks. While overall trends indicate that food prices will be reasonable, some concerns remain about the impact of exceptional weather. Studies by the USDA based on data for the last hundred years in major producing areas indicate, for example, that the North American maize crop is likely to be as much as 20 percent below trend once every 10 years (i.e., by 50 million tons in 1985 terms). By itself, such an event would raise prices appreciably. Even after short-run adjustments, including the diversion of maize from the live-

stock sector, in the worst case the real price of maize could remain as much as 20-25 percent higher than before such a shortfall. The same studies indicate that production shortfalls in maize elsewhere, or in other grains, are not likely to have as significant an impact on world markets in the 1980s, the feed economy being likely to be dealt with by transferring to human consumption some of the feeds in store or being fed to livestock, with price rises kept within reasonable bounds. The high prices associated with temporary shortages are then likely to call forth enough production increases to restore trend balances in the long run, both in the US and elsewhere.

Man-made Shocks. Far more serious than potential weather-induced supply problems is the possibility that government policies will create serious global shortages. The 1972-74 food market dislocations were caused partly by US policies designed to reduce stocks left over from a previous period of oversupply. Equally important was the willingness of major industrialized country importers to insulate their domestic food prices from changes in world prices, which made the corresponding market adjustment more difficult.

There is some cause for concern that governments may respond excessively to current 1983 surpluses. Given the political importance of protecting farmers' incomes in France, Germany, Japan, or the US, any surplus which depresses rural incomes creates pressure for counteraction. If, as a result, production were to be controlled, an induced "shortage" might occur as the byproduct of well meaning efforts to reduce prior surpluses.

The main danger is therefore likely to be associated with unanticipated changes in government farm policies in the EEC, US, or USSR occuring along with exceptionally adverse weather conditions in the US and--unlikely but possible--concurrently poor harvests elsewhere. While the immediate price effects of such shifts are impossible to forecast, there is no reason to expect that they would be greater than those experienced in 1973-74, which were less serious than was widely believed at the time. They can also be expected to prove equally shortlived; the feed substitution adjustment mechanism is robust, and there are enough sources of alternative supply to ensure a *de facto* ceiling on possible price rises. Premiums of 10 percent above market prices might be paid in a few cases to obtain supplies immediately, but there seems no reason to expect a dangerous breakdown of the system or dramatic changes in world prices.

In the future as in previous decades, the most dangerous food security problems are likely to be local ones caused by political breakdowns or deliberate policy decisions which increase the vulnerability of households. In Kampuchea, Timor, Uganda and a dozen other regions in the past decades, war, civil strife or restrictive policies have

prevented relief agencies and local administrators from saving lives that need not have been lost. The likelihood of political decay and international tension does not seem to be subsiding. In addition to the three million refugees in Africa, there are now approximately three million on the borders of Afghanistan, and displaced persons make up an unknown total in Southeast Asia. These populations stay alive largely on the basis of international charity.

To conclude, while there are real risks in relying on prices and supplies in an international environment, experience and analysis since the mid-1970s suggests that these risks have often been exaggerated. Over the last decade, trade in general and developing country imports of grain in particular have risen very much faster than in any previous period. This has taken place even though grain prices have been less stable than before, and even though binding intergovernmental trade agreements were lacking. Further, while there is still a danger that man-made instability could jeopardize the security of food supplies, there is no reason to expect any systematic breakdown either in supply or in the ability to adjust, which has served the world well since the mid-1970s.

[An original article]

Note: The views expressed here are the author's and not necessarily those of the World Bank.

Estimating Food Aid Needs: How Much and To Whom?

Barbara Huddleston

[If food security needs are quantified by estimates of per capita calorie needs minus the sum of current production plus planned imports, world food aid needs are about triple the volume of actual shipments. But food aid should not be provided unless disincentives to farmers are avoided and new demand for food by the malnourished is created.]

It is not possible to estimate accurately the level of the requirement for food aid for some year in the future. Nevertheless, there are some general principles which may be used to determine the current level of a country's need for food aid on an annual basis. Using these principles and projecting past trends, one can estimate rough orders of magnitude for the future requirements of developing countries in the aggregate, although such estimates do not represent precise indicators of likely future requirements in individual countries.

Quantification of the food aid requirement provides an upper limit to the amount which could be effectively utilized. For most countries, the actual demand for food aid is lower than this because economic conditions and management constraints restrict the amount which can be put to good use. Some economic environments are more hospitable than others to food aid programs which reach the poor. In hospitable environments food aid can be given in two ways. One is to use food aid to create additional demand, thus avoiding disincentive effects for domestic agriculture. However, the administrative costs of such programs are usually high: either countries must provide scarce management skills them-

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selves, or rely on expatriate voluntary agency personnel. This cost imposes one kind of constraint on the quantity of food aid a country can use effectively.

Another way is to sell aid food on the open market, perhaps at subsidized prices for consumers, and use the proceeds to support farm prices or otherwise contribute to agricultural development. While disincentives resulting from open market sale could be avoided in the right policy environment, it is often politically difficult to shift away from a set of policies which use imports to support a cheap food policy while taxing domestic agriculture.

As a practical matter, therefore, increases in food aid should be phased in gradually in accordance with a recipient country's strategy for effective utilization. Constraints on donors with respect to developmental allocation and multi-year programming must also be loosened before food aid can achieve its full potential for simultaneously feeding the poor and contributing to sustained economic growth. This article first presents a quantification of the maximum food aid requirement, then goes on to discuss economic and management constraints and their practical implication for food aid policy.

Quantifying the Need

Various attempts have been made by FAO and others to suggest criteria and estimate the need for food. The approach followed here is to estimate total import requirements to meet a nutritional standard, and then to estimate the portion of this which is likely to be met with commercial imports, based on assumptions about ability to pay. These assumptions take into account per capita income levels, trends in export earnings, and ratios of foreign exchange reserves to total merchandise imports. The residual between total import requirements and estimated commercial imports then represents the requirement for food aid if consumption targets are to be met.

GNP per capita serves as a good proxy for several pertinent criteria. Higher levels of GNP are generally associated with strong export sectors and hence with capacity to finance needed cereal imports on commercial terms. Also, high levels of per capita GNP practically assure that food supply will be adequate in the aggregate, and middle levels increase the likelihood that food supplies will be adequate. Based on data for 1976-78, countries with a per capita income of $900 or more in 1977 dollars should no longer require food aid.

For middle-income countries, those with per capita incomes between $300 and $900 in 1977 dollars, per capita supply availability is one indicator of need, and export strength is another. Looking first at the situation in the recent past, the mean for per capita staple crop production averaged 211 kg per year for all developing countries in

1976-78, that is, almost 2,000 calories per day. In countries at or above the mean, this amount, if distributed equitably, would be sufficient to maintain adequate consumption levels in most countries, even where some portion of the total is consumed by livestock. The adequacy of the food supply is also indicated by the total per capita availability of calories in relation to the FAO/WHO standard established for each country. Although this standard has been challenged as being too high and it does not take equity considerations into account, it serves as a rough guide as to whether a country has a sufficient food supply to feed its total population adequately.

Export strength represents the ability of a country to finance necessary cereal imports on commercial terms. It is reflected in the performance of the export sector vis-a-vis the total economy, as measured by the ratio of export earnings to GNP, and by the size of the foreign exchange reserve, as measured by the ratio of foreign exchange holdings to average annual merchandise imports. Again for 1976-78, the mean export/GNP ratio for all developing countries was 0.324. Countries with higher ratios could therefore be judged to have relatively stronger export sectors, and countries with lower ratios could be judged to have relatively weaker export sectors. Some countries with relatively stronger export sectors nevertheless exhibit weakness in their foreign exchange position, as evidenced by a foreign exchange/import ratio of less than 0.25. (The export/GNP ratio may sometimes be misleading, since there is a tendency for smaller countries to have higher ratios due to their smaller internal markets. Where larger countries have low export/GNP ratios but good export growth rates, their basic strength is captured instead by the foreign exchange reserve indicator.)

On the basis of these indicators, the 34 middle-income countries can be classified as follows:

A. exports or reserves strong, production strong;
B. exports and reserves weak, production strong;
C. exports or reserves strong, production weak;
D. export and reserves weak, production weak.

Countries where both indicators are strong are assumed not to need food aid. Countries with high per capita staple crop production but weak balance of payments are also assumed not to need food aid. They may face balance of payments problems if per capita intake does not reflect the adequacy of aggregate supply and they wish to import to make up the apparent deficiency; but the apparent food problem seems to be more a problem of distribution and market performance than of supply availability. Countries with weak food supply and mixed or weak balance of payments positions are assumed to need food aid. However, the amount is constrained by imposing the condition that food aid will be given only when the cost of cereal imports adequate to meet nutritional needs exceeds five percent of export earnings. The fluctuations in this

ratio can be quite large; by fixing the current average ratio as a balance of payments criterion for determining eligibility for food aid, the food aid can be made to respond automatically to changes in countries' food security requirements. This criterion assures that countries will meet their obligation not to substitute food aid for commercial imports, while being easier to administer than the current "usual marketing" requirement used by the FAO Committee on Surplus Disposal.

For middle-income countries, the amounts of food aid requirement estimated in this way for 1976-78 are compared to actual amounts of food aid received (Table 1). In all, nine countries would have needed 4.5 million tonnes, compared to 31 countries which actually received 2.7 million tonnes. For balance of payments reasons, Egypt would have required more food aid than it actually received, although the total amount of its import requirement would have been less. Because of low per capita intake and balance of payments problems, Ghana and Peru would have required substantially more than they received.

All low-income countries are assumed to require food aid for balance of payments support, even in those few cases where per capita intake is adequate by FAO/WHO standards. Since their export sectors are weak and available foreign exchange is badly needed for capital goods imports during the early stages of growth, this seems a reasonable assumption. Also, reliable data for examining a more precise set of indicators to determine eligibility for food aid are often lacking. The amount of the requirement is estimated as the gap between per capita staple crop production and imports required to meet the minimum per capita nutritional standard, with an allowance for commercial imports equal to two percent of export earnings. This last condition forces countries to accept some responsibility for allocating their own foreign exchange to cereal imports before becoming eligible for food aid, without imposing a substantial burden on their scarce resources.

Out of the 39 low-income countries shown in Table 1, only Burma, Burundi, and Madagascar did not require food aid, and only Bhutan and Uganda did not receive food aid, in 1976-78. The total received amounted to 4.3 million tonnes, with roughly 80 percent going to Asia. The amount required was far larger, amounting to 27.3 million tonnes, but again nearly 80 percent would go to Asia.

This requirement is far above the 17 to 18.5 million tonnes estimated by FAO as a realistic food aid requirement for 1985, taking into account both need and absorptive capacity. Nor is the total much reduced by increasing the ratio of export earnings which countries pay for commercial cereal imports before becoming eligible for food aid. Indeed, the principal reason for the large size of the total requirement is the five-fold increase over actual receipts estimated for Bang-

Table 1

Food aid requirements, 1976-78

middle-income countries	*1976-78 actual (000 tonnes)*	*1976-78 required (000 tonnes)*
A. Exports or reserves strong: production strong		
Total	128	0
B. Exports and reserves weak; production strong		
Total	216	0
C. Exports or reserves strong; production weak		
Bolivia	31	196
Egypt	1,778	2,527
Mauritania	35	138
Peru	18	819
Yemen DR	11	146
Zambia	22	28
Other	302	0
Total	2,197	3,854
D. Exports and reserves weak; production weak		
Dominican Republic	25	60
Ghana	57	251
Senegal	74	322
Other	41	0
Total	197	633
Grand Total	2,738	4,487

low-income countries	*1976-78 actual (000 tonnes)*	*1976-78 required (000 tonnes)*
Asia		
Bangladesh	1,022	5,205
Bhutan	0	26
Burma	8	0
India	1,019	13,876
Indonesia	636	516
Nepal	2	225
Pakistan	464	464
Sri Lanka	346	1,030
Total	3,497	21,004
Latin America		
Haiti	54	429
North Africa/ Middle East		
Afghanistan	31	934
Sudan	64	87
Total	95	1,021
sub-Saharan Africa		
Angola	9	33
Benin	8	66
Burundi	4	0
Central African Republic	2	17
Chad	29	277
Ethiopia	67	1,796
Gambia	9	39
Guinea	29	197
Guinea-Bissau	17	13
Lesotho	18	30
Madagascar	8	0
Malawi	3	15
Mali	25	153
Mozambique	97	498
Niger	55	190
Rwanda	12	54
Sierra Leone	7	88
Somalia	70	295
Tanzania	120	530
Togo	11	67
Uganda	0	246
Upper Volta	24	237
Zaire	29	84
Total	653	4,925
Grand Total	4,299	27,329

ladesh, and the fourteen-fold increase for India, to meet nutritional needs. Similar results were obtained by USDA in its estimation of nutrition-based requirements for 1982-83; had these countries received amounts sufficient to eliminate hunger, this estimate puts their combined requirements at 19 million tonnes. While the actual size of the need may be considerably less if new, lower estimates of the amount of malnutrition are correct, there is no question that significantly larger amounts are needed to alleviate hunger in these two countries.

Apart from supply considerations, there is reluctance on the part of both donors and recipients to consider increasing food aid by such large amounts for fear the donated commodities will increase dependence on imports and discourage growth in domestic agricultural production. There is also concern that local markets, ration systems, and targeted distributions could not handle sudden large increases in commodity availability. But it may be mentioned that, among low-income countries, India and Bangladesh are among the more advanced in terms of thoughtful consideration of appropriate price and distribution policies and creation of public distribution mechanisms which reinforce rather than hinder the operation of local markets.

If present trends continue, what will the picture look like by 1990? First, the number of higher income countries increases from 26 in 1976-78 to 42 in 1990, so the number of countries potentially eligible for food aid drops from 73 to 57 (see Table 2). Second, total food imports increase from 75 million tonnes in 1976-78 to over 175 million tonnes in 1990, under the highest-growth scenario.

Table 2

Per capita income by region, in 1977 dollars

	1976-78			*1990*		
	< 300	*300-900*	*> 900*	*< 300*	*300-900*	*> 900*
	(no of countries)			*(no of countries)*		
Asia	8	6	5	6	4	9
Latin America	1	12	11	1	5	18
North Africa/ Middle East	2	8	7	2	5	10
sub-Saharan Africa	23	13	3	16	18	5
Total	34	39	26	25	32	42

Table 3

Cereal imports and food aid requirements in 1990, by region, four scenarios[1]

	income-based		*nutrition based*		*consumption based*		*import-based*	
	imports	*food aid*	*imports*	*food aid*	*imports*	*food aid*	*imports*	*food aid*
				million tonnes				
Asia[2]	24.1	7.3	24.4	20.3	30.1	5.5	57.2	5.4
Latin America[3]	14.6	0	7.2	0	21.2	0.3	59.9	0.2
North Africa/Middle East[4]	24.1	3.5	24.4	4.3	42.4	10.1	41.5	8.7
sub-Saharan Africa[5]	29.2	5.8	28.1	10.8	15.1	3.6	17.8	3.8
Total	92.0	16.6	84.1	35.4	108.8	19.5	176.4	18.1

[1] All four scenarios are based on estimation of a gap between demand for cereals and domestic production in 1990. They are derived as follows:

Income-based: *per capita* consumption at 1975 base plus amount necessary to meet income-generated demand at higher levels of *per capita* income, assuming high rates of growth in GNP and UN medium variant population growth rates. Production at 1961-78 trend growth rates.

Nutrition-based: *per capita* consumption at amount necessary to provide 100 per cent of FAO/WHO nutritional minimum, assuming *per capita* consumption at 1975 base plus cereal equivalent of calorie gap and projecting to 1990 using UN medium variant population growth rates. Production at 1961-78 trend growth rates.

Consumption-based: aggregate trend consumption of staple foods minus aggregate trend production of staple crops, projected at 1961-78 growth rates.

Import-based: trend imports projected at 1961-78 growth rates.

[2] India receives almost 10 mn tons of food aid under the nutrition-based scenario, but nothing under the other three. Bangladesh also receives nearly 10 mn tons under this scenario, compared to 3-6 mn tons under the other scenarios. Republic of Korea and People's Republic of China account for the higher total import figure under the import-based scenario.

[3] Mexico accounts for 35 mn tons of the total import figure under the import-based scenario, compared to 4 mn tons or less under the other scenarios. As with Korea and the PRC, this results from applying a high import growth rate to a high volume base.

[4] The two large recipients of food aid in North Africa/Middle East are Egypt and Morocco, with Morocco taking nearly 1 to 4 mn tons and Egypt 3 to 7 mn tons.

[5] Under the nutrition-based scenario for Africa, Ethiopia, Tanzania and Zaire each account for at least a million tons more than under other scenarios. In addition, certain Sahelian countries also require additional food aid to meet nutritional requirements. The differences in total import requirement under different scenarios is accounted for largely by differences in the volume projected for Nigeria.

Nearly 20 million tonnes of food aid would be required in 1990 by the 57 potential recipients under three of the four scenarios shown in Table 3 (see Table footnote 1. for definitions of scenarios). Under the nutrition-based scenario, the total quantity required by eligible countries in 1990 would be 35 million tonnes; since income-generated growth in demand is not included in this scenario, the total food import figure comes to only 85 million tonnes. Although the nutrition-based food aid requirement is higher in 1990 than in 1976-78, some low-income countries, particularly India, show improvement. Countries with large nutrition requirements in 1990 include Bangladesh, Ethiopia, Tanzania, Zaire, and the landlocked countries of the Sahel. Whether these countries can absorb and effectively utilize the quantities they will apparently require during the coming decade is a much-debated issue.

Methods of Using Food Aid

There is still considerable controversy over whether food aid acts as a disincentive to cereal production in a developing country. In a closed, self-sufficient economy with little or no trade, food aid introduced for open market sale must depress prices. Since food producers in most developing countries do respond to price changes, the availability of food aid will act as a disincentive to production unless offsetting policy interventions are introduced. However, the pure case of a closed economy where food aid adds to market supply with no offsetting policy interventions is not typical of actual conditions in most countries receiving food aid. For one thing, most developing countries do trade with the rest of the world, even though some are virtually self-sufficient in staple foods. Thus the closed economy model is not appropriate. In an open economy where trade takes place, the chances of food aid depressing prices and discouraging domestic production are much slimmer.

When a country trades, it seeks to keep its domestic prices in equilibrium with world market prices. Trading countries which do not regulate imports and are price-takers in world markets can be expected to import the quantity required to keep domestic cereal prices in line with world prices. To keep domestic prices at their equilibrium level after the introduction of food aid, commercial imports will have to be reduced by the amount of the food aid. In this situation there is no price disincentive for domestic producers, but neither is there any additional demand creation for consumers. The only benefit to the country is the foreign exchange saving created by the lower dollar cost of its cereal imports.

The majority of developing countries fall into yet another category, that is, trading countries which do regulate prices. In these countries, the effect of food aid on demand, price, and production depends primarily on the nature of government interventions in domestic food markets. Sometimes governments are pursuing policies which distort incentives to farmers, quite apart from whether or not food aid is available. For the most part, distortions take the form of cheap food policies which governments pursue on behalf of urban consumers. If food aid forms a large share of total consumption, its availability may induce countries to pursue such policies more vigorously than they otherwise would. But for most countries food aid does not represent a very significant share of total staples consumption--less than five percent in 81 out of 99 cases. In such countries other macroeconomic policies such as overvalued exchange rates, export taxes, procurement quotas at low official prices, and outright fiscal subsidies provide the means for maintaining low consumer prices in urban areas.

Where food aid reinforces government's pursuit of cheap food policies, proceeds from the sale of the food aid may be used as a resource

to offset the potential disincentive effects by creating additional domestic demand, by financing a price wedge which provides income support to farmers, or by supporting a stocks program to even out seasonal price fluctuations.

Food aid which is used to support demand creation among low-income groups has double benefits. First, it avoids the production disincentive which additional food sold on the open market might otherwise create. Second, it makes a positive humanitarian contribution toward enhancing nutritional status among groups where the hunger problem is most acute. Even though some leakage will almost inevitably occur, since families rarely spend 100 percent of an income increment on food, the contribution to improved quality of life can be substantial. In some countries, the use of food aid is valid only in certain years when domestic harvests are poor and relief aid is needed for rural areas. Use of food aid to meet variable food security requirements, in addition to meeting immediate food needs, can contribute to production stability and long-run growth because poor farmers no longer have to sell or mortgage their capital assets to pay for tomorrow's food. In other countries, chronically malnourished groups may require supplementary food for some period of time. In an economic environment which is favorable to labor-intensive development, food aid targeted at these groups can provide a wage good which enables supply to keep pace with demand without inflationary pressure. Eventually, as growth continues, the aid can be phased out and replaced with domestically-produced or commercially-imported supplies.

For a variety of reasons, demand creation may not always be the preferred use of food aid. First, administrative mechanisms for reaching target groups in rural areas are frequently non-existent or very costly. Second, given their resource limitations, many governments attach more importance to stimulating domestic production than to alleviating chronic malnutrition. Third, if there are to be demand-creating subsidies for food consumption, many governments find it difficult to offer these to the voiceless poor while denying them to the more vocal and politically powerful middle classes.

An alternative strategy for using food aid effectively takes these factors into account. It entails creating additional demand either by fixing official retail prices at subsidized rates or by forcing domestic market prices below world market prices by using food aid commodities as an additional source of supply for open market sale. To prevent a disincentive effect on production, this policy of subsidizing consumer prices must be offset by a policy which fixes producer prices at a level higher than that established by the market. Since the food aid represents a free or low-cost resource to government, most, if not all of the funds generated by open market sales can be used to finance this price wedge. Other uses of counterpart funds are possible, but

none has as clear-cut and immediately stimulative effects in a situation where the food aid represents additional supply and is used to support a cheap food policy for consumers.

Another possibility with which some countries are experimenting entails using food aid to support the creation of working stocks and food security reserves. This requires investment in storage and transport facilities, and the operation of a government procurement and price support program which acquires and releases stocks with a view to stabilizing market prices for both producers and consumers. This approach permits some government intervention through the use of food aid and domestic stocks to avoid sharp fluctuations in price, but it permits the market to establish the long-run equilibrium price, and thus prevents distortions in either demand or supply. This is feasible wherever the country needs to import a portion of its total domestic supply but lacks financial resources to import adequate amounts. Of course, in countries which are self-sufficient in foodstuffs at adequate levels of per capita consumption, governments should be able to operate procurement and price stabilization programs entirely from domestic supplies.

To summarize, effective utilization of food aid can be accomplished without farm disincentives in three ways: through the use of food aid for demand-creating, targeted distribution programs; through the sale of food aid at subsidized prices for consumers and use of the proceeds to finance farm price supports; and through creating food security reserves to stabilize prices at market equilibrium. However, each approach requires management skills, and a sustained political commitment to an agriculture-based growth strategy.

Some Practical Implications

Two classes of countries continue to require food aid. One is the group of middle-income countries which are beginning to solve their more serious food problems, but still need balance of payments support. For the most part, these countries should be reaching the point where they can manage targeted food distribution programs without external assistance. However, to maintain the level of cereal imports necessary to supply domestic markets at stable prices, these countries may need concessional assistance from time to time. The amount of assistance required will fluctuate from year to year according to the level of domestic crop production and the volume of cereal imports required, the level of world cereal prices, and the levels of export earnings and foreign exchange reserves in relation to the value of total import requirements and debt servicing obligations. Since the amount required will fluctuate from year to year, the most appropriate form of support is program aid, where food commodities are sold on the open market and proceeds are used for general budgetary support in a policy environment conducive to agricultural growth.

Reasons for not increasing food aid to particular countries in this group may include the inappropriateness of food aid commodities for local markets, lack of handling capacity for additional imports, pricing policies which subsidize urban consumption but do not stimulate domestic production, and marketing systems which hinder the free flow of local cereals from production centers to market centers.

The other class of countries requiring food aid is the low-income group where inadequate levels of domestic food production and lack of purchasing power combine to depress consumption for large numbers of poor people. Until these countries graduate to a higher income status, it can be assumed that they face pressing balance of payments problems, and that imports of cereals will have to be financed primarily with concessional or grant assistance. The amount of food aid required will therefore be the amount of additional imports needed to bring per capita consumption up to minimum nutritional standards for different sexes, age groups, and activity levels. This amount equals the difference between domestic production and the total supply required to meet effective market demand plus unsatisfied nutritional needs. In low-income countries there will be a continuing requirement for food aid until per capita incomes reach higher levels. Multi-year commitments could therefore be envisioned at levels equal to the anticipated gap between desired consumption and trend production, with some provision for a gradual increase in commercial imports as the balance of payments situation improves, and annual adjustments which respond to fluctuations in production.

Since the primary objective of food aid in low-income countries is to improve nutritional status by increasing demand and supply simultaneously, the most appropriate form of support is project aid where commodities are used to finance targeted food subsidies, or distribution programs which reach the poor directly with additional food. As pointed out above, this approach could be managed to benefit the malnourished with relatively little effect on domestic market prices. In addition, projects which are seasonal or which vary in size with local production conditions also reduce the risk of hunger for small farmers and landless laborers by providing an income supplement when harvests are poor, or when food prices are high. This contribution to rural stability can have important long-run benefits for agricultural growth and development.

In many low-income countries marketing systems are not well developed and price policies do not serve the interests of farmers. Food aid can facilitate policy reform by providing a food security cushion. With a small back-up reserve, governments can introduce price and procurement policies which allow markets to operate freely within a price band that protects the interests of both consumers and producers.

Problems in increasing food aid to low-income countries may include the high administrative cost of targeted programs and lack of local management personnel, lack of data on the nutritional status and consumption behavior of intended beneficiaries, unsuitability of food aid commodities for local diets, and rigid marketing systems and price policies which tax producers for the benefit of consumers. If data and management constraints can be removed, narrowly-targeted programs may achieve their objective of improving nutritional status, even though government policies are not oriented toward rural development. But broader subsidy programs or projects which use food aid in support of development-related activities are not likely to achieve their objectives over the long term unless the policy direction is also changed.

These problems suggest that food aid cannot and should not be provided in the amounts projected in Tables 1 and 3. Nevertheless, the projections supply a clear indication of need, particularly in the low-income countries where the hunger problem is most serious. The extent to which these various difficulties prevent countries from absorbing the quantities of food aid which they appear to need will differ from country to country, and their effect on capacity to use additional food aid effectively is difficult to quantify.

An alternative approach for estimating food aid requirements for individual countries on an annual basis would avoid this problem by simply starting with the existing program level and asking, first, is the quantity now being received effectively utilized? Second, if yes, how much additional quantity could be effectively utilized, and in which existing programs? Third, if no, could the same or a larger quantity be effectively utilized in some other program mode? In countries where existing levels are small and represent primarily aid to targeted distribution programs, sizeable increases over this very low base might be envisioned, providing some agency is prepared to accept the administrative responsibility. In countries with well-established distribution networks and adequate handling capacity to move grain from port to rural markets, sizeable increases in food aid to support dual price systems, food security reserves, and market reforms could also be envisioned. In countries which lack good transport networks, where rural markets are not well-integrated with urban centers, and where there are few distribution centers from which targeted programs can operate, food aid should only be increased as complementary resources are provided to overcome these constraints. If these countries are moving toward a favorable policy environment, food aid increases might be programed in increments of, say, 10 percent a year, along with programming of other development assistance resources to assure effective use of the food aid.

The growth process which will ultimately free low-income countries from dependence on food aid will not be accomplished within the

next decade. If program planning begins now for incremental increases in food aid leading to levels of the order of magnitude of those suggested above for 1990, it will be from that point that the growth process can really take off and the eventual phase-out of food aid can occur. The record of today's middle-income countries suggests that this transformation can be accomplished. To use food aid effectively while pursuing such a strategy requires a strong policy commitment from recipient countries. Equally important, however, are the commitments donor countries must make to avoid using their food resource in counterproductive ways. These commitments include: need-base allocations policies, simpler approval procedures, and timely deliveries.

Conclusion

There is a case for increasing food aid by two to three times its current volume, with about 90 percent of the total going to low-income countries. But the justification rests on the proposition that both recipients and donors will commit themselves to policies which assure that the food aid will be used in the service of long-term agricultural development and economic growth. Once need has been established, the extent of this commitment should therefore determine the amounts and allocations of food aid increases. With grain surpluses again accumulating, it is timely to focus attention on ways to improve food aid programming to meet immediate human needs and to contribute to the eventual elimination of world hunger.

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